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This month's contributors include...

ROB BANINO
SCIENCE JOURNALIST

How do you image the invisible? Rob reveals how infrared data from ESO's VLT is turned into the photos we know and love. *Page 63*

JAMIE CARTER
TRAVEL WRITER

Jamie reports on how locals in the first Dark Sky City are tackling the urban menace of light pollution. *Page 72*

MARK PARRISH
DIY EXPERT

Mark's latest two-part project is a simple tabletop tracking mount for taking long exposure astrophotos. *Page 81*

ELIZABETH PEARSON
STAFF WRITER

Elizabeth looks back at all that Hubble has achieved so far, from its unexpected finds to its most beloved images. *Page 38*

Welcome

Looking back at 25 years of the Hubble Space Telescope

Over the past quarter of a century one telescope more than any other has given us a new appreciation of the cosmos, and that's the Hubble Space Telescope. This month we celebrate 25 years of the orbiting observatory: on page 38, Elizabeth Pearson looks back at its remarkable career, which has contributed data to 11,000 scientific papers and played a part in some of the major astronomical finds of recent years, from black holes to exoplanets. We also look at the visual impact Hubble has made over its long lifetime in orbit with an *Eye on the Sky* special starting on page 6, where we've chosen our very favourite images from the telescope's huge archive.

We move closer to home on page 32, where Will Gater explains how you can take stunning wide-field images with a DSLR and the lens that comes with it. If you're inspired and capture a stunning nightscape photo of your own, get your entry in to the 2015 Insight Astronomy Photographer of the Year competition before the closing date on 15 April!

The imaging theme carries on in this month's *Reviews* where, continuing in our quest to bring you the latest and most exciting astrophoto and observing equipment, Pete Lawrence takes a look at the new Sony α7S full frame camera. Find out what he made of its incredible top ISO of 409600 on page 90. We've not neglected sketching this month either. Turn to page 44 to find out how to make accurate and valuable drawings of the planet Jupiter.

Enjoy the issue!

Chris Bramley Editor

PS Next issue goes on sale 16 April.

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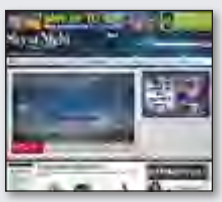
Editorial enquiries
BBC Sky at Night Magazine, Immediate Media Co Bristol Ltd, Tower House, Fairfax Street, Bristol, BS1 3BN

Sky at Night LOTS OF WAYS TO ENJOY THE NIGHT SKY...

TELEVISION
Find out what *The Sky at Night* team will be exploring in this month's episode on page 19



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NEW TO ASTRONOMY?
See *The guide* on page 78 and our online glossary at www.skyatnightmagazine.com/dictionary

FEATURES

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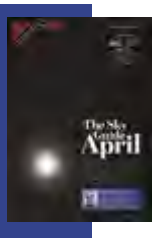

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EDITORIAL
Editor Chris Bramley
Art Editor Steve Marsh
Production Editor Kev Lochun
Staff Writer Elizabeth Pearson
Reviews Editor Paul Money

CONTRIBUTORS
Paul Abel, Maggie Aderin-Pocock, Rob Banino, Jamie Carter, Adam Crute, Jon Culshaw, Lewis Dartnell, Glenn Dawes, Russell Deeks, Ian Evenden, Eagle Gamma, Mark Garlick, Will Gater, Olivia Johnson, Pete Lawrence, Chris Lintott, Hazel Muir, Chris North, Mark Parrish, Steve Richards, Steve Sayers, Giles Sparrow, Paul Sutherland, Stephen Tonkin, Emily Winterburn, Paul Wootton

ADVERTISING SALES
Advertising Managers Steve Grigg (0117 314 8365), Tony Robinson (0117 314 8811)
Inserts Laurence Robertson (00 353 87 690 2208)

PRODUCTION
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Ad Services Manager Paul Thornton
Ad Co-ordinator Emily Thorne
Ad Designers Cee Pike, Andrew Hobson
Reprographics Tony Hunt, Chris Sutch

LICENSING
Director of Licensing and Syndication Tim Hudson
International Partners' Manager Anna Brown

MARKETING
Head of Circulation Rob Brock
Head of Marketing Jacky Perales-Morris
Marketing Executive Ethan Parry
Head of Press and PR Jen Howard (020 7150 5733)

PUBLISHING
Publisher Jemima Ransome
Managing Director Andy Marshall

MANAGEMENT
Chairman Stephen Alexander
Deputy Chairman Peter Phippen
CEO Tom Bureau

BBC WORLDWIDE, UK PUBLISHING
Director of UK Publishing Nicholas Brett
Head of UK Publishing Chris Kerwin
UK Publishing Coordinator Eva Abramik
UK.Publishing@bbc.com
www.bbcworldwide.com/uk--anz/ukpublishing.aspx

EDITORIAL ADVISORY BOARD Andrew Cohen, Deborah Cohen, Michael Ewing, Julian Hector, Clare Matterson, Jonathan Renouf

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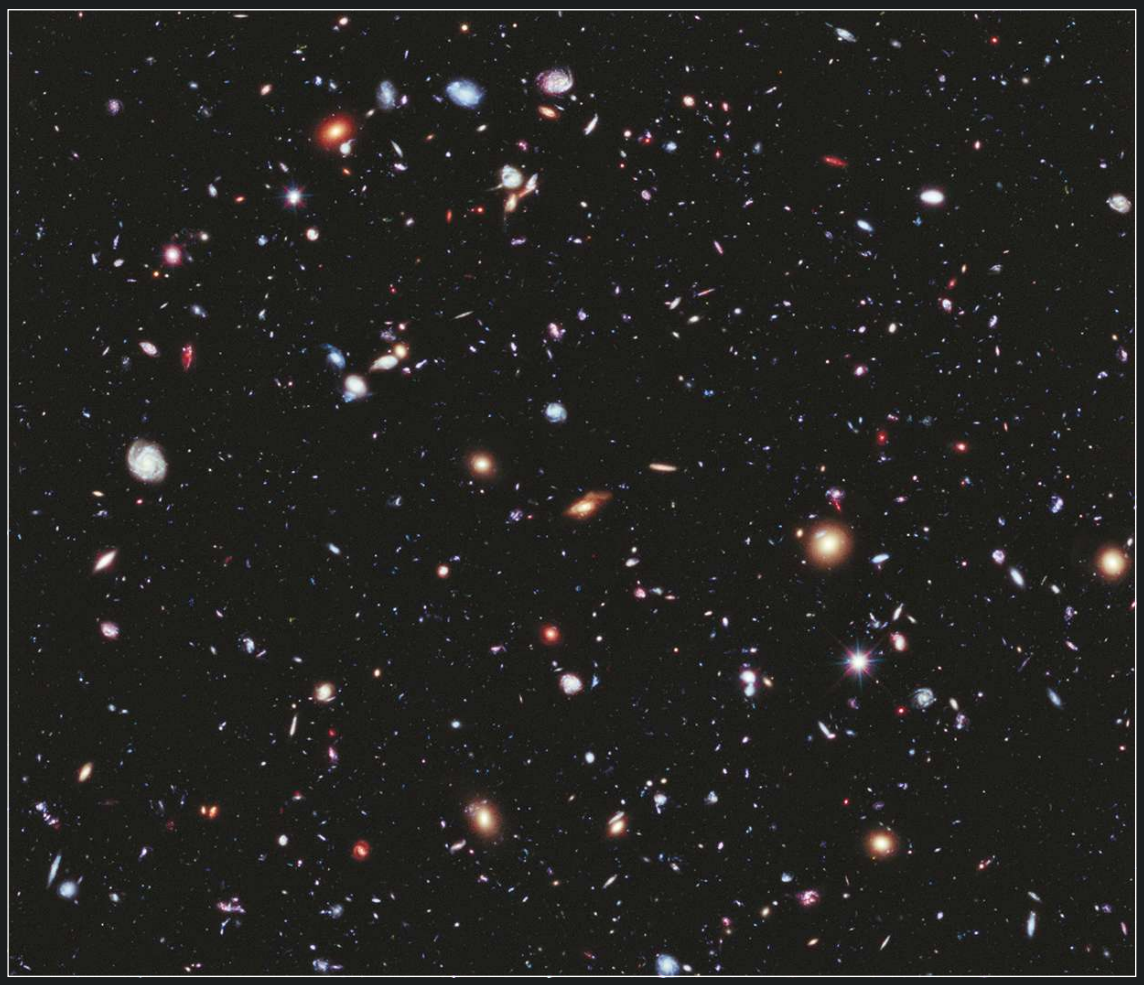
Mystic mountain

HUBBLE SPACE TELESCOPE
1-2 FEBRUARY 2010

This cosmic crag in the southern constellation of Carina opens our celebration of 25 years of jaw-dropping images from the veteran space telescope

This craggy pillar of dust forms part of the Carina Nebula, an extremely active star-forming region lying some 7,500 lightyears from Earth in the southern constellation of Carina, the Keel. Streamers of hot, ionised gas can be seen flowing off the edges of the three-lightyear-tall structure, eroded by radiation and fast winds. The prominent jets seen at the top and centre of the image, which are known as HH 901 and HH 902 respectively, are being fired off by nascent stars within the Carina Nebula. These young stars will eventually burn away all of the dust.



◀ Deeper still

HUBBLE SPACE TELESCOPE
25 SEPTEMBER 2012

Hubble has produced many awe-inspiring images, but none more so than this one, the Hubble eXtreme Deep Field. Created by repeatedly scanning the same patch of sky over 10 years, this image shows an area with an angular diameter less than that of the full Moon, yet it contains some 5,500 individual galaxies, the most distant of which are 13.2 billion years old – just 0.6 billion years younger than the Universe itself.

▼ A deadly dance

HUBBLE SPACE TELESCOPE, 11 NOVEMBER 2013

These two galaxies will literally be the death of each other. NGC 4038 and NGC 4039, known as the Antennae Galaxies, have been engaged in a gravitational tug-of-war for the past few hundred million years. Eventually, they will fuse into one.

▲ Eye in the sky

HUBBLE SPACE TELESCOPE, 16 JANUARY 1996

This startling sight is the Hourglass Nebula, which lies 8,000 lightyears from Earth in the southern constellation of Musca, the Fly. Dubbed 'the eye of God' by some, this iconic image has appeared everywhere from the cover of *National Geographic* to the artwork of a Pearl Jam album.

◀▼ Then and now

**HUBBLE SPACE TELESCOPE
5 JANUARY 2015**

Since launching in 1990, Hubble has undergone a number of hardware and software upgrades that have improved its imaging capabilities. Just how much they've improved can be seen by comparing this image of the Pillars of Creation – trunks of dust and gas in the Eagle Nebula – taken in January 2015 (left) with the original (below) that Hubble captured in 1995.

◀ In the clouds

HUBBLE SPACE TELESCOPE, 26 MARCH 2003

In 2002, a dim star in the constellation of Monoceros suddenly got much, much brighter. The cause of the flare-up isn't yet known, but light from the brief flash echoed around the star's surrounding dust shell for a long while afterwards – enabling Hubble to capture images like this one, and giving scientists a much better understanding of the structure of such shells.

NASA/ESA/STSCI/AURA, NASA/ESA/STSCI/J. HESTER AND P. SCOWEN, NASA/ESA/H. E. BOND (STSCI), NASA/ESA/STSCI/AURA, NASA/ESA/HUBBLE SM4 ERO TEAM, NASA/ESA/J. M. APELLÁNIZ

Petal power ▶

HUBBLE SPACE TELESCOPE
20 APRIL 2011

Created for Hubble's 21st birthday back in 2011, this image shows interacting galaxies UGC 1810 (top) and UGC 1813 (below) – jointly known as Arp 273. The upper galaxy's distinctive rose-like shape is caused by the gravitational pull of the companion galaxy below.

▼ Hot wings

HUBBLE SPACE TELESCOPE
9 SEPTEMBER 2009

The Butterfly Nebula, NGC 6302, looks serene and beautiful. In reality it is anything but. Its 'wings' are enormous clouds of gas, heated to 20,000°C, which has been given off by a dying star that lies right in the centre of the nebula.

Bubble vision ▶

HUBBLE SPACE TELESCOPE
11 DECEMBER 2006

This striking picture of large emission nebula NGC 6357 clearly shows how intense ultraviolet radiation from the star cluster Pismis 24 (bottom centre, blue) has burned away the gas and dust around it, creating a bubble inside the nebula.

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Bulletin

The latest astronomy and space news written by **Hazel Muir**

PLUS CUTTING EDGE

Our experts examine the hottest new astronomy research papers

Exoplanet has vast rings

The dusty ring system of J1407b dwarfs that of Saturn

ASTRONOMERS BELIEVE THEY have found an alien world with a ring system around 200 times wider than Saturn's. If the rings around this exoplanet, known as J1407b, surrounded Saturn itself, they would be easily visible from Earth and many times larger than the full Moon.

The planet's host Sun-like star, J4107, was detected in archived observations from the SuperWASP project in 2012. Curious eclipses of the host star suggested that it has a planet 10 to 40 times the mass of Jupiter surrounded by a disc of dust, which sometimes blocks up to 95 per cent of the star's light for days. Now an analysis led by Matthew Kenworthy from Leiden Observatory in the Netherlands has shown that the planet has more than 30 rings, each tens of millions of kilometres wide.

Gaps in the rings hint that they've been swept out by moon formation. "The eclipse lasted for several weeks, but you see rapid changes on timescales of tens of minutes as a result of fine structures in the rings," says Kenworthy. The ring system is thought to contain roughly the same mass as the Earth in light-obscuring dust particles.

▸ See Comment, below

The huge ring system is believed to exist around a correspondingly giant planet, around 10-40 times the size of Jupiter

RON MILLER

COMMENT

by Chris Lintott

This discovery will be another blow for the beleaguered interstellar tourism industry. It's been argued in the past that Saturn might be one of the wonders of the Milky Way, a uniquely beautiful sight that would attract visitors from far and wide.

Part of the logic underlying this optimism was the idea that the rings might be a transient feature, something that appeared recently and would soon disappear. If other planets with rings are common that appears less likely. We're lucky the rings appear to transit, but that luck suggests there must be many other similar systems out there.

The team, and I suspect other astronomers, are already looking for other similar systems, but they'll also be keeping a close eye on J1407b. Only one transit event has been seen, and so for amateurs, this might be a system worth monitoring – a dip in its brightness might herald these majestic rings slowly crossing in front of their parent star.

CHRIS LINTOTT co-presents *The Sky at Night*

NEWS IN BRIEF

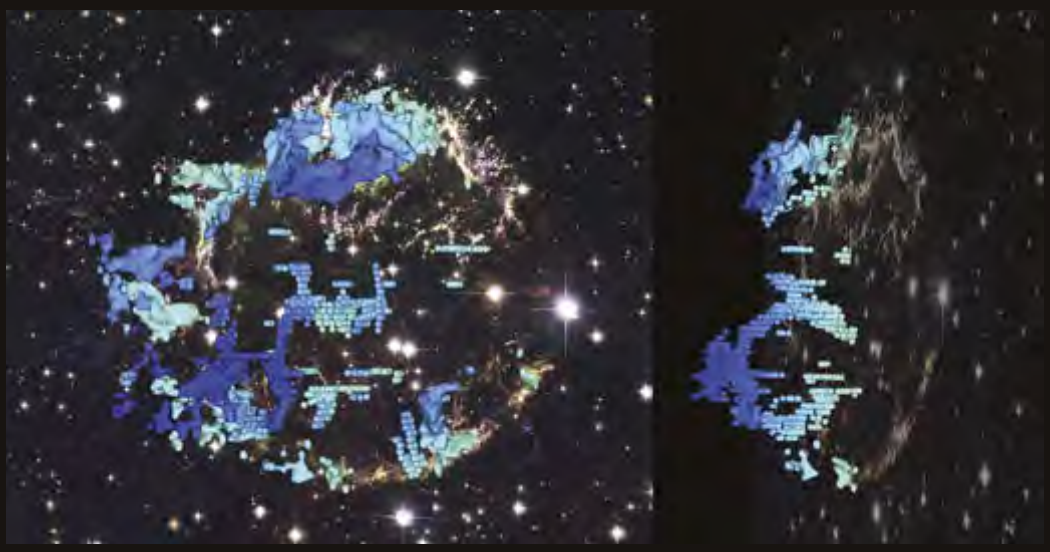
RADIO BURST CAPTURED LIVE

Astronomers using the Parkes Radio Telescope in Australia have, for the first time, seen a 'fast radio burst' (FRB) happening in real time. FRBs are short, sharp flashes of radio waves. It's not clear what causes them, but catching the burst 'live' allowed astronomers to quickly follow up the observation with other telescopes, revealing that it had no X-ray, ultraviolet, infrared or optical counterpart. "That in itself rules out some candidates, such as long gamma-ray bursts and nearby supernovae," says Mansi Kasliwal from the Carnegie Institution in Pasadena, California.

MARS METEORITE'S DARK PAST

A meteorite found in 2011 has given scientists a better picture of Mars's crust. Unlike other Martian meteorites, 'Black Beauty' turns out to be a dead ringer for the dark plains where Mars's bedrock is exposed, suggesting it's typical of the majority of Mars's surface. The rock is a breccia, an aggregate of different rocks welded together. Analyst Jack Mustard from Brown University calls it "dark, messy and beautiful".

SWINBURNE ASTRONOMY PRODUCTIONS, NASA, D. MILISAVLJEVIC (CFA) & R. FESEN (DARTMOUTH)/BACKGROUND IMAGE: NASA/ESA AND THE HUBBLE HERITAGE TEAM, NASA/CXC/SAO, W. JAESCHKE AND D. PARKER, C. HARRISON/A. THOMSON/BILL SAXTON/NRAO/AUI/NSF/NASA, NASA/JPL-CALTECH



▲ A 3D map of Cassiopeia A, coloured to represent the varying speeds of different gas emissions

The anatomy of an exploded star

Supernovae can leave behind a mass of bubbles

DESPITE BEING ONE of the most well-studied supernova remnants in our Galaxy, Cassiopeia A still throws up surprises. Most recently, astronomers have shown that it is made up of some half a dozen giant bubbles.

Cassiopeia A (pictured below) formed when a massive star about 11,000 lightyears from Earth exploded at the end of its life. As the star blew itself apart, hot radioactive matter rapidly streamed outward from the star's core, mixing and churning outer debris.

The complex physics behind these explosions is difficult to model, even with simulations on powerful supercomputers. However, by carefully studying young supernova remnants like Cassiopeia A – which is only about 340 years old, as seen from Earth – astronomers can investigate the various key processes that drive these catastrophic blasts.

Now Dan Milisavljevic from the Harvard-Smithsonian Center for Astrophysics in Massachusetts and Rob Fesen from Dartmouth College in New Hampshire have further clarified this by observing Cassiopeia A using a 4m telescope at the Kitt Peak National Observatory in Arizona. This allowed them to measure the expansion velocities of extremely faint material in the supernova remnant's interior and create a 3D map of it.

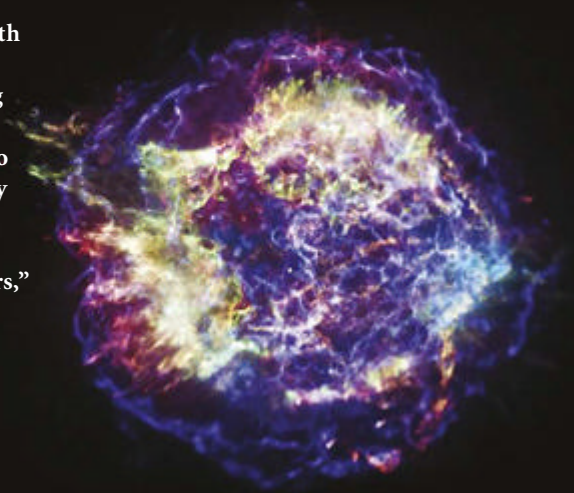
"We're sort of like bomb-squad investigators," says Milisavljevic. "We examine the debris to learn what blew up and how it blew up."

The results showed that Cassiopeia A has several massive cavities. The two most well-defined bubbles are roughly three and six lightyears wide, and the entire arrangement has a structure much like Swiss cheese. The large cavities help to explain the previously observed large rings of debris that make up the outer shell of the supernova remnant, which is much more easily observed.

Theory suggests that the bubble-like cavities were created by plumes of radioactive nickel, which were generated during the stellar explosion. This nickel would naturally decay to form iron, so Milisavljevic and Fesen predict that the bubbles in Cassiopeia A should be enriched with iron, possibly with as much as a tenth of the mass of the Sun.

However, this iron-enriched interior debris hasn't been detected so far, so a new generation of telescopes may be needed to find the 'missing' iron and confirm the origin of the supernova remnant's bubbles.

www.noao.edu/kpno



The mystifying plumes of Mars

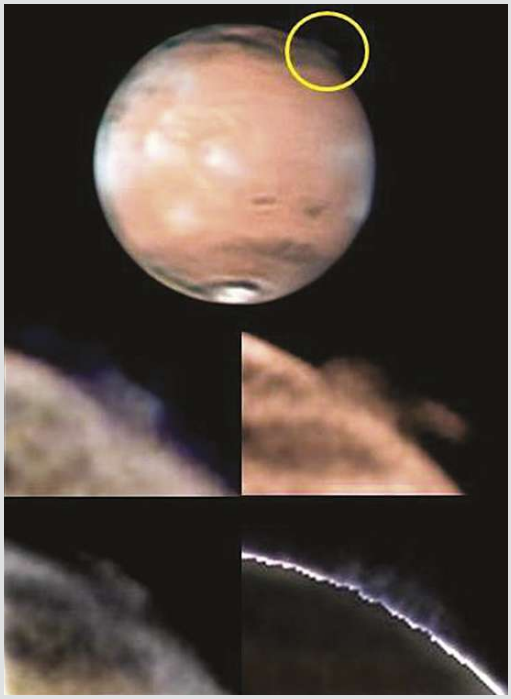
Vast clouds on the Red Planet remain unexplained

STRANGE ENORMOUS PLUMES in the atmosphere of Mars continue to baffle scientists. Amateur astronomers spotted the high plumes in Mars's southern hemisphere in March and April 2012, and follow-up observations showed they rose to altitudes of more than 250km.

The plumes developed over a period of less than 10 hours, covered an area up to 1,000km wide and remained visible for around 10 days. "The reported plumes are extremely unexpected," says Agustín Sánchez-Lavega from the University of the Basque Country in Spain.

Archived observations by the Hubble Space Telescope have revealed that a high plume developed on Mars in May 1997. Sánchez-Lavega and colleagues have since explored the idea that such plumes may be related to clouds of water-ice, clouds of frozen carbon dioxide particles or auroral activity, but none of these explanations accounts for their enormous size. The search for an answer to this mystery goes on.

www.hubblesite.org



▲ **Plumes spotted in the Martian atmosphere in 2012 still haven't been properly accounted for**

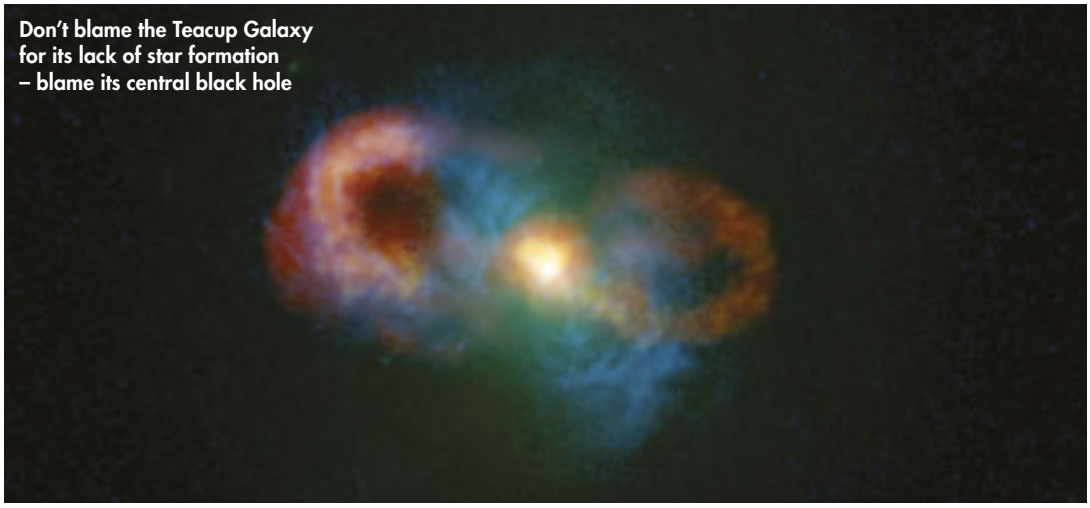
A GALACTIC STORM IN A TEACUP

USING THE VERY Large Array in New Mexico, astronomers have discovered surprisingly energetic activity in a galaxy previously considered 'boring'. The finding shows that a giant black hole at the galaxy's centre is hindering its ability to form stars.

"A supermassive black hole is explosively heating and blasting around the gas in this galaxy, and as a result, transforming it from a star-forming galaxy into one devoid of gas that can no longer form stars," says team leader Chris Harrison from Durham University. For years, astronomers have seen this happen in bright, massive elliptical galaxies, where powerful jets of material from supermassive black holes have removed or destroyed the raw materials for star formation. But it was unclear whether this is true of less extreme galaxies, which better represent the majority.

To find out, Harrison's team studied a fairly dull galaxy, formally known as J1430+1339 but nicknamed the 'Teacup' due to its distinctive shape. The observations showed that it, too, is being stripped of gas at speeds of up to 1,000km per second by jets from a black hole.

www.vla.nrao.edu



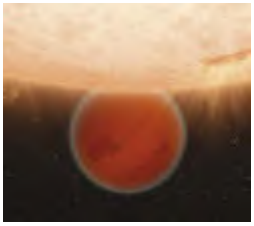
Don't blame the Teacup Galaxy for its lack of star formation – blame its central black hole

NEWS IN BRIEF

'TWINKLE' TO PROBE EXOPLANETS

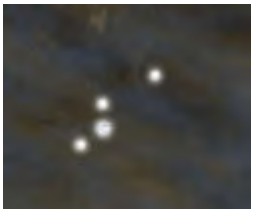
A British satellite named Twinkle is set to give radical new insights into the chemistry, formation and evolution of exoplanets. The satellite should be launched within the next four years.

"Twinkle is a very ambitious mission," says Giovanna Tinetti from University College London, who is the lead scientist for the project. "It will be the first dedicated to analysing exoplanet atmospheres and will give us a completely new picture of what these worlds are really like."



FLEDGLING MULTIPLE STAR SYSTEM SPOTTED

Astronomers have spied a multiple star system during its earliest stages. Using radio telescopes including the Very Large Array, they found three dense fragments of a gas filament near one very young star. The fragments should form stars in about 40,000 years. "This is the first time we've been able to study these young systems in formation," says Jaime Pineda from the Swiss Federal Institute of Technology.



CUTTING EDGE

Our experts examine the hottest new research

Is gravity really constant?

An alternate method of explaining the Universe is gathering interest, but does the evidence back it up?

▲ **Most spiral galaxies have a central bulge, the tell-tale sign of a merger having occurred**

When astronomers talk about what we know about the Universe, we can seem overconfident. The more absurd the feature of the Universe, the harder we often seem to work to defend it.

Take the case of dark matter. When considering things on scales from the cosmological to those inhabited by individual galaxies, what we see can best be explained by claiming that most of the Universe's 'stuff' is in the form not of ordinary particles and atoms, but of dark matter. There is something profoundly unsettling about this as an explanation: it feels like special pleading, and until we've actually established what dark matter is, it will continue to feel that way.

Plenty of scientists agree and alternative explanations to dark matter abound. Most fall under the banner of something called Modified Newtonian Dynamics (MOND) which, as a paper by Françoise Combes of the Paris Observatory makes clear, might have consequences for galaxy formation. MOND as a theory dates back to the early 1980s. The idea is that rather than assume that the Universe is filled with invisible matter, one can fiddle with the laws of gravity to explain what is observed. The most common MOND theories make the gentle suggestion that gravity might act a little differently in the emptiest regions of the Universe.

It seems a modest proposal, and it has long been known that fiddling with gravity in this way can, with care, resolve some of the observational puzzles that lead less bold researchers to invoke dark matter. But messing with gravity has consequences, many of which are explored in Combes's paper, the first I've seen that links modified gravity to the shape of galaxies produced.

The most significant event in the history of many systems is a major merger, and mergers would be much less frequent in a MONDian Universe. After all, if gravity is weaker in some places than others, then it will be less likely to cause protogalaxies to come together. So to test MOND, all we need to do is look around and see if the galaxies that surround us show signs of frequent mergers.

Think of a typical spiral galaxy, made up of a thin disc with a fat bulge at the centre. The odds are that the stars in that bulge are there because of a merger, having been kicked up out of the disc by the interaction between the merging galaxies. Bulgeless galaxies, therefore, should be merger-free – and if MOND is right, we should see a lot of them.

> "Bulgeless galaxies should be merger-free – and if MOND is right, we should see a lot of them"

This amounts to a testable prediction, and it turns out that a suspicious number of galaxies in the local Universe might well be bulgeless. Texas astronomer John Kormendy has argued that both the Milky Way and the Andromeda Galaxy might fit the definition, while my own Galaxy Zoo project has thrown up a number of bulgeless systems.

Is this enough for me to abandon my belief in dark matter? Frankly, no. Other ways of accounting for the mix of galaxies we see around us exist, and conventional gravity, as studied not just by Newton but by Einstein too, is too well tested for me to abandon it based on this sort of prediction.

What is exciting, though, is that enough astronomers are taking the idea of MOND seriously enough to do this kind of work. I don't think there's anything wrong with our understanding of gravity – but that's no reason not to test out alternative theories whenever we can.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

CHRIS LINTOTT was reading… *Explaining the formation of bulges with MOND* by F Combes
Read it online at http://arxiv.org/abs/1501.03603

NEWS IN BRIEF

STRANGE GALAXY POSES PUZZLE

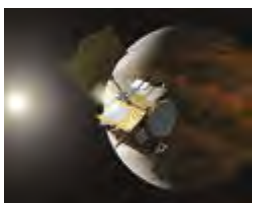
Scientists have solved a puzzle that arose after citizen scientists taking part in the Milky Way Project noticed something odd in images captured by the Spitzer Space Telescope. The volunteers spotted what appeared to be hundreds of bright yellow, fuzzy objects in star-forming regions.

A team led by Charles Kerton from Iowa State University has now shown that the 'yellow balls' in the false-coloured images are newly formed stars 10 to 40 times as massive as the Sun.

"This is a nice example of people looking at something in the Universe and saying – 'that's different' – and then passing it on to professional astronomers," says Kerton.

JAPANESE PROBE RETURNS TO VENUS

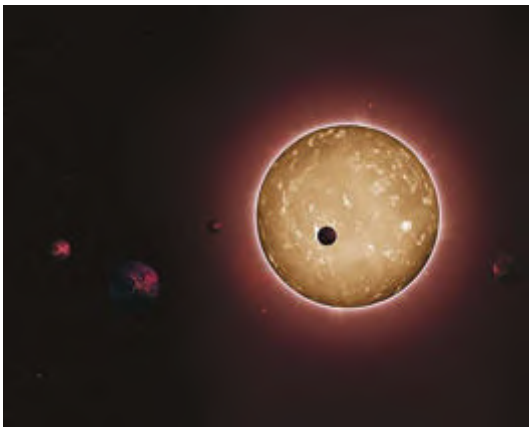
Japanese space agency JAXA will attempt to place its Akatsuki (meaning 'dawn') spacecraft into the orbit of Venus in December this year. The probe was launched in May 2010 but failed to successfully enter Venus's orbit on the first attempt.



NASA/JPL-CALTECH, COURTESY OF AKIHIRO IKESHITA, PETER DEVINE AND TIAGO CAMPANTE/UNIVERSITY OF BIRMINGHAM, ESO/L. CALÇADA

The Solar System's 'mini-me'

Kepler 444's rocky planets could have hosted life in the young Universe



▲ **Kepler 444's planets all have tight orbits; they were discovered when they transited the star, dimming its light**

AN ANCIENT PLANETARY system dating back to the dawn of our Galaxy appears to be a miniature version of our own inner Solar System. Sun-like star Kepler 444 has five planets in orbit around it, ranging from the size of Mercury to the size of Venus. The system is thought to have formed 11.2 billion years ago, when the Universe was less than a fifth of its current age, making it the oldest known system of terrestrial-sized planets.

"We now know that Earth-sized planets have formed throughout most of the Universe's 13.8-billion-year history, which could provide scope for the existence of ancient life in the Galaxy," says study leader Tiago Campante from the University of Birmingham.

www.nasa.gov/kepler

WHITE DWARFS FACE VIOLENT CLASH

A CLOSE PAIR of white dwarf stars – the extremely dense remnants of Sun-like stars – look set to collide in a dramatic explosion. The two stars lie about 4,000 lightyears away in planetary nebula Henize 2-428 and have a total mass of 1.8 times that of the Sun, a record-breaking mass for a white dwarf pair.

The stars orbit each other in just four hours and astronomers say they will collide around 700 million years from now, triggering a violent supernova. "Until now, the formation of Type Ia supernovae by the merging of two white dwarfs was purely theoretical," says study co-author and ESO fellow David Jones. "The pair of stars in Henize 2-428 is the real thing."

www.oan.es

Double central stars may also be responsible for giving nebulae such as Henize 2-428 a lopsided appearance

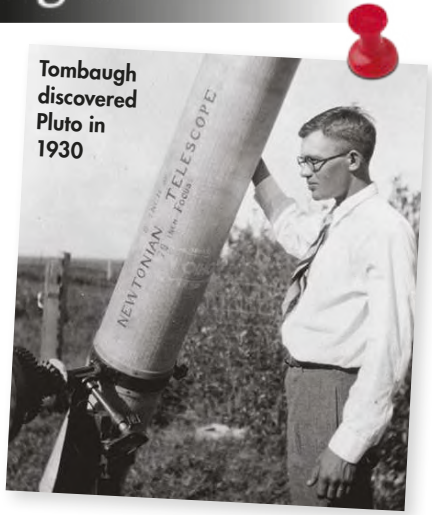
Looking back The Sky at Night

April 1975

On 30 April 1975, *The Sky at Night* broadcast discussed the outer planets with guest Clyde Tombaugh, the American astronomer who discovered Pluto in 1930. Pluto was regarded as an outer planet of the Solar System until it was reclassified as a dwarf planet in 2006.

Today, only the giant planets Jupiter, Saturn, Uranus and Neptune are categorised as outer planets. During the 1970s, they were viewed as very enigmatic worlds. But this changed after NASA launched its Voyager 1 and 2 probes in 1977. Between them, the probes beamed back fascinating observations of all four planets, along with 48 of their moons and unique ring systems.

Tombaugh died in 1997, but he would no doubt have been thrilled that Pluto is about to become centre stage, with NASA's New Horizons spacecraft heading for a rendezvous with it in mid-July.

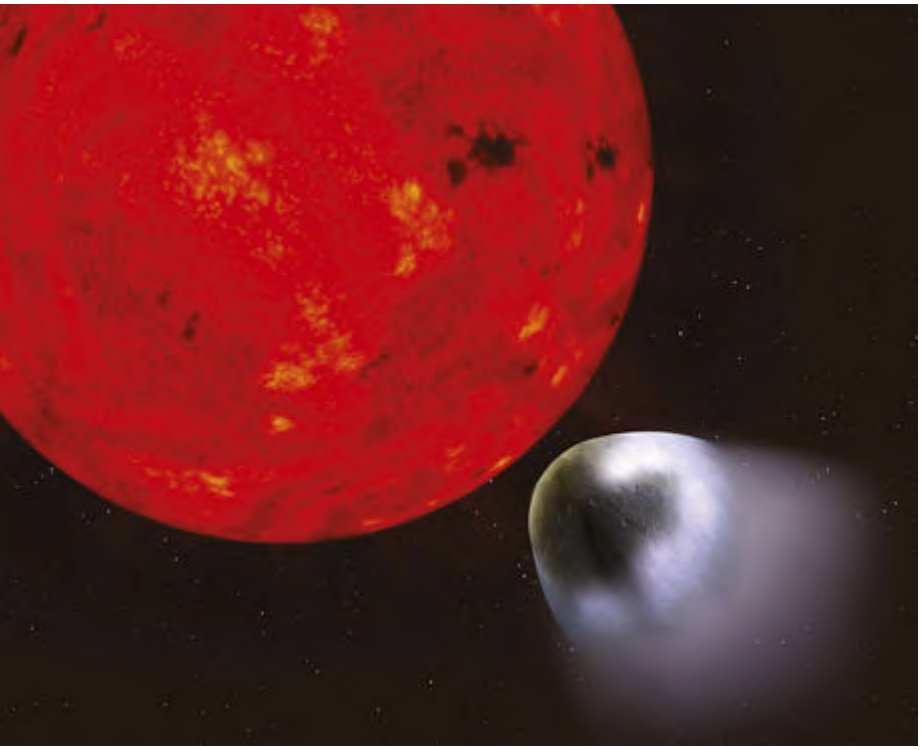


CUTTING EDGE

Our experts examine the hottest new research

M-dwarfs and exoplanets

Hostile mini-Neptunes could migrate inwards to become habitable super-Earths



ISTOCK

▲ **A Neptune-like planet migrating inwards within its system would shed its atmosphere along the way**

Some of the most interesting real estate in the Galaxy, in terms of the prospects of extraterrestrial life, are the planets orbiting M-class red dwarf stars. Not only are such stars very abundant – there are around 10 times more red dwarfs in our Galaxy than there are Sun-like stars – they are also exceedingly long-lived. Sipping their hydrogen fuel like stellar misers, they can remain on the main sequence for trillions of years. And, thanks to their small size and low luminosity, the tell-tale stellar wobble that betrays the presence of an exoplanet is much more obvious, giving us a much better chance of being able to detect any that are there. In fact, around 20 of the 30 closest stars to Earth are M-class dwarfs, but because they are so dim none of them are visible to the naked eye.

However, all is not rosy with red dwarfs for the prospects of life. The habitable zone lies in a very tight ring around these stars and so any planets that reside here are likely to have formed very dry and to have become tidally locked. What's more, M-dwarfs can be very tempestuous when young, and lash habitable planets with radiation from energetic flares.

LEWIS DARTNELL is an astrobiologist at University of Leicester and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

Rodrigo Luger at the University of Washington says that one way in which habitable worlds could exist around M-dwarfs could be if a planet started out in the colder, outer regions of the nascent star system, where it would be born with abundant water, and then migrated inwards to the habitable zone.

But such planets may also have gathered thick gaseous envelopes around them, similar to mini-Neptunes, which would limit habitability. So the question is, could mini-Neptune planets around M-dwarf stars shed their crushing atmospheres and allow the rocky surface beneath to develop life? Luger and his colleagues call this kind of reformed world a habitable evaporated core, or HEC, and they have modelled the evolution of gassy planets to work out how likely they are to form habitable worlds. They considered all sorts of factors, including how the upper atmosphere of planets can be driven away by the energetic ultraviolet and X-ray radiation from a fiercely active young star, how the orbit of planets can migrate in towards their star over time and how the rotation of a planet can be slowed by tidal interactions with the star's gravity.

> "Around 20 of the 30 closest stars are M-class dwarfs, but none are visible to the naked eye"

What they found was that HECs can indeed form from mini-Neptunes starting with around twice the mass of Earth, and with as much as 50 per cent of this as a thick atmosphere of hydrogen and helium. But this mechanism for shedding away the crushing atmosphere relies on the planets migrating early in their lives (within 10 million years) and the young red dwarf having a long period of activity and flaring. But considering the fact that planets formed out of material already in the habitable zone are likely to be too dry for oceans and thus life, this evaporation process of mini-Neptunes could be the most important way for creating wet, Earth-like planets around this common type of star.

LEWIS DARTNELL was reading… *Habitable Evaporated Cores: Transforming Mini-Neptunes into Super-Earths in the habitable zones of M-Dwarfs* by Rodrigo Luger et al
Read it online at http://arxiv.org/abs/1501.06572

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What's on

Our pick of the best events from around the UK

Sunspots

Royal Observatory Greenwich, London, 30 April, 7pm-8.30pm

▲ **The evening event will explore the links between science and art**

Huddersfield-born poet Simon Barraclough's recently published book *Sunspots* is the centrepiece of this evening, which explores connections and collaborations between artists and scientists. Joining Barraclough in a panel discussion will be solar astrophysicist and *The Sky at Night* presenter Dr Lucie Green – who among her many other accomplishments was chief observer for the Japanese space agency solar mission, Hinode – and leading British independent film-maker Jack Wake-Walker, who'll be showing a series of short films inspired by Barraclough's poetry. There will also be readings of the poems themselves. Tickets for this event cost £8 and advance booking is highly recommended.
www.rmg.co.uk

BEHIND THE SCENES

THE SKY AT NIGHT IN APRIL

BBC Four, **12 April**, 10pm (first repeat BBC Four, **16 April**, 7.30pm)*

April's episode celebrates the success of the venerable Hubble Space Telescope

SDO/NASA, STSCI AND NASA, STEPHEN TONKIN, ISTOCK

HUBBLE AT 25

For 25 years the Hubble Space Telescope has been showing us the cosmos as we've never seen it before. This month *The Sky at Night* reveals the top five greatest images the orbiting observatory has produced – images that have astounded us, transforming our understanding of the Universe and of our place in it.

Check www.bbc.co.uk/skyatnight for subsequent repeat times

Binocular Astronomy

Hertford Astronomy Group, Welwyn Garden City Golf Club, Welwyn Garden City, 8 April, 8.15pm

Stephen Tonkin, the man behind our monthly *Binocular tour*, explains how to get the most out of these often under-used observing tools – from buying the right pair to mounting them and selecting targets. Free for members, £3.50 for non-members.
www.hertsastro.org.uk

The International Year of Light 2015

Astronomical Society of Edinburgh, Augustine United Church, Edinburgh, 10 April, 8pm

INTERNATIONAL YEAR OF LIGHT 2015

Dr Giles Hammond of the University of Glasgow explains the origins, activities and objectives of this global, year-long UN initiative to raise awareness of light science and its applications, and how they might solve some of the world's biggest problems. Entrance is free.
www.astronomyedinburgh.org

Impacts From Space: Death, Destruction and Dinosaurs

Torbay Astronomical Society, Torquay Boys' Grammar School, Torquay, 23 April, 7.30pm

Prof Paul Roche of the University of South Wales reveals all you ever wanted to know about asteroid impacts, including the cataclysmic one that's thought to have wiped out the dinosaurs 66 million years ago. Free for members, £3 adult non-members, £1 for under-18 non-members.
www.torbayastro.org.uk

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.

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A PASSION FOR SPACE

with **Maggie Aderin-Pocock**

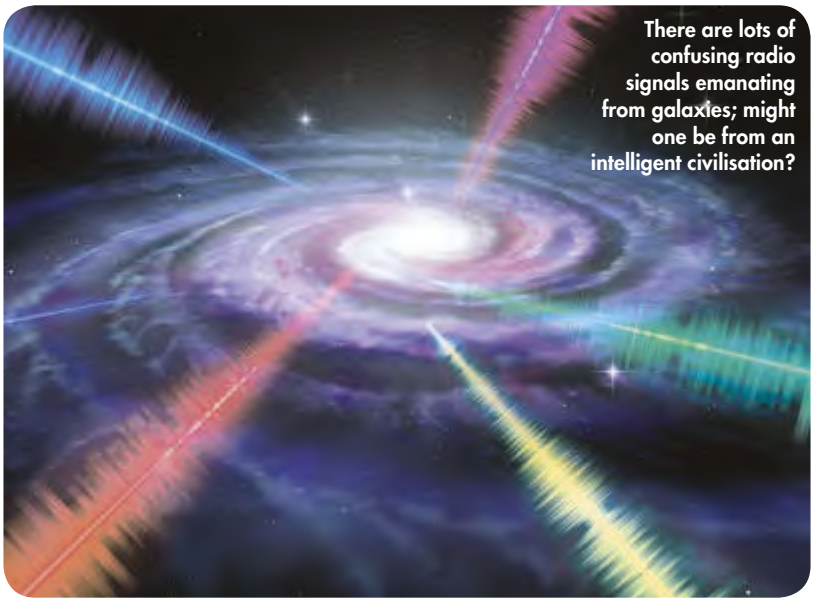
The Sky at Night presenter wonders whether alien life might be trying to contact us from afar

The desire to meet aliens has always been with me. But the more I have learned about the Universe, the more I believe that they are probably out there and the less I believe that I am likely to meet one.

They seem likely to be out there due to the numbers. Our Galaxy contains around 200 billion stars and now we are able to detect some of the exoplanets around them. Even if we assume that there is on average just one planet orbiting each of these stars, that means there are a whole heap of planets out there. If we scale up to the Universe, then we estimate that there are around 100 billion galaxies, so the number of planets out there is pretty mind boggling. With so many planetary options available, it seems quite likely that there is some form of life out there too.

Yet on the question of little green men visiting us from afar I am less convinced. The problem is that the Universe is very, very vast. To travel from our star to its stellar next-door neighbour as fast as we can with current technology (Voyager speeds of 17.5km/s), the journey would take around 76,000 years.

If travel looks hard then let's just send a message at the speed of light. But as our Galaxy is around 100,000 lightyears in diameter and even our nearest star is 4.28 lightyears away, even conversations are likely to be slow.



There are lots of confusing radio signals emanating from galaxies; might one be from an intelligent civilisation?

ISTOCK X 2

How would we tell?

But if aliens were trying to contact us, what would their signal look like? Well, it is likely to be in the form of radio waves. We use these to send signals across the Solar System to communicate with our space probes, and these waves are relatively undisturbed by interstellar dust and gas. The signal would need to be a persistent one, and it would need to be structured so we can discern it from the naturally occurring radio noise that is out there. These parameters could be the hallmarks of an alien communication.

The only problem is that we have detected this sort of signal before. The first one was picked up by the amazing Dame Prof Jocelyn Bell Burnell when she was a PhD student in 1964. It was a bit of an anomaly until she was able to detect others. They turned out to be coming from pulsars, super-dense remnants of supernovae that send out beams of radio waves which sweep past our planet with incredibly accurate frequencies, hence the pulse.

If our hallmark signature for alien communication can be met by a naturally occurring pulsar then what sort of signal should we be looking for? Well, one of the other differences between a naturally occurring radio source and an artificial one is the range of frequencies that it contains. Natural signals tend to be broadband whereas artificial ones usually have a much narrower spectrum. Couple this with the fact that a signal coming from a planet in orbit about a star will have a Doppler shift as it moves towards us and away from us in its orbit round the star, and there may be a number of ways to tell if the signal we are picking up is potentially alien.

Maggie Aderin-Pocock is a space scientist and co-presenter of *The Sky at Night*

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JON CULSHAW'S EXOPLANET EXCURSIONS

Jon takes his brand new spaceship on a test flight to beautiful Kepler 438b

For this trip, I'm going to need a bigger spaceship. The trusty old Cruiser Globe has been showing concerning signs of fragility as a result of the unfathomable lightyears travelled on our exoplanet excursions. So I've retired the Globe to the agricultural Lancashire barn where it resides between trips – it'll do grand for future quick hops to the Moon to watch Earthrise with a cup of tea.

My new vessel has similarities to the interior of Carl Sagan's Ship of the Imagination from *Cosmos*, though it's not quite as huge as the inside of that particular craft, which appeared like a cross between an aircraft carrier and Royale's nightclub in Southport. My ship, named The Perihelion, is like a soft-top roadster version of Carl's spaceship, with an impressive array of interstellar travel capabilities. Its exterior is less like a dandelion seed, more a hybrid of a Bob Lazar UFO and a Ford Capri.

The Perihelion's maiden trip should be to somewhere familiar, so I'll travel back to the constellation of Lyra where once I visited the stunningly beautiful world, Kepler 62e. It seems appropriate that this trip should be to the 1,000th Kepler world to be verified. Orbiting red dwarf star Kepler 438, 470 lightyears from us, is Earth-like planet Kepler 438b.

This rocky world is 1.12 times the size of Earth. Its parent star, being a red dwarf, is smaller and cooler than the Sun, so the habitable zone is comparatively close. It only takes 35.2 days for Kepler 438b to complete one orbit, a nice month-like period that's pleasingly similar to that of our Moon.

From the surface of this world, the star Kepler 438 hardly seems like a dwarf: it looms imposingly large and scarlet, like a colossal, perfect sphere of volcanic magma. There's 40 times more radiation reaching this planet's surface than is the case with Earth. The surface light is far greater than we'd be used to on a midsummer day, but thankfully the Perihelion's light balancers filter the powerful luminosity to a tolerable level.

Kepler 438b also receives a much stronger solar wind from its star than Earth does from the Sun. I'm hoping the planet's atmosphere has a strong enough magnetic field to help it survive the ferocity of the satr's highly energetic particles, which stream towards it as if shot out of a water cannon.

After the setting of the parent star, there's an alluring orange glow to the night sky and behind me there's a wonderful exoplanetary Belt of Venus. The curve of Kepler 438b casts a shadow into its own atmosphere. The ochre glow of the sky fades into the shadow curve of deep, oaky brown.

The great strength of the stellar wind, coupled with the robustness of the atmosphere and its magnetic field, gives rise to the most dazzlingly vivid alien aurora, with luminosity like mobile disco lasers hitting the wall of a church hall. The indigo, crimson and fluorescent olive shades of this aurora have a brightness powerful enough to cast shadows. With hypnotic subtlety, these auroral shadows ripple against the alien terrain like the silhouetted lady from the title sequence from Roald Dahl's *Tales of the Unexpected*.

Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

MAIN ILLUSTRATION: MARK GARLICK, SPACECRAFT: PAUL WOOTTON, PHOTO: EMMA SAMMS

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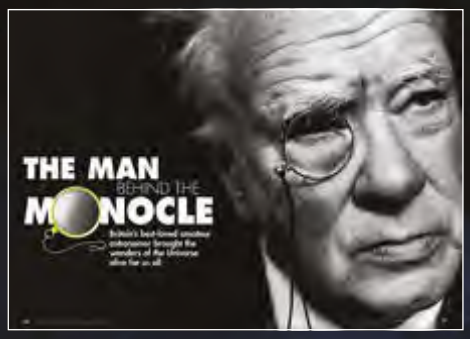

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This month's top prize: four Philip's books

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Heather Couper and Nigel Henbest's *Stargazing 2015*, Patrick Moore's *The Night Sky*, Storm Dunlop's *Practical Astronomy*, and *Stargazing with Binoculars* by Robin Scagell and David Frydman.

PHILIP'S

SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Have your say at **twitter.com/skyatnightmag** and **facebook.com/skyatnightmagazine**

@skyatnightmag asked: What could the two bright spots on Ceres that were observed by Dawn on 19 February be?

@DamWev Being in the centre of a large crater, I would think there's a good chance of it being bright material related to the impact.

@deepskymike Must be fresh(ish) impact areas by meteorites revealing the ice underneath.

Evelyn Gillies Light reflecting off a twin telescope, looking at the Dawn spacecraft!

Neil Walters It could be the Clangers!

ED HENGEVELD/PHILIP CORNELLE

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MESSAGE OF THE MONTH

The power of the pencil

Just over two years ago I purchased my first telescope, a Sky-Watcher Explorer 200P (a *BBC Sky at Night Magazine Group Test* winner). To begin with it was extremely rewarding just to find and view objects in the magazine, gradually ticking them off the Messier list. However after being shown the wonders of the night sky by experienced members of the South East Kent Astronomical Society, I realised that the more seasoned members were able to pick out more detail through the eyepiece than I was able to. It was then that I decided to start writing notes and drawing my observations. This has made my time at the telescope much more than casual viewing through the eyepiece and my astronomy has become much more rewarding. The Moon has to be a personal favourite – the view through a telescope never fails to disappoint!

Emma Parfitt, Deal, Kent

What a wonderful lunar sketch, Emma. I'm delighted that we've played a part in your journey to becoming a dedicated amateur astronomer – there are many more rewards to come! ***– Ed***

The heroic Hubbles

This April astronomers worldwide will celebrate the 25th anniversary of the Hubble Space Telescope. So I commissioned Dutch space artist Ed Hengeveld to capture both the telescope and its namesake astronomer in a single image. The painting shows Edwin Hubble among the stars above the dome of the 100-inch telescope on Mount Wilson, while the space telescope observes M31.

Philip Corneille, De Haan aan Zee, Belgium

A fitting memorial to a remarkable scientist and his eponymous telescope, Philip. Turn to pages 6 and 38 to see our celebration of the space telescope. ***– Ed***

Ignorance is bliss

Reading Hazel Muir's take on the Rosetta probe's cometary findings and Chris Lintott's comment on the delivery of water to the primordial Earth (*Bulletin*, February, page 10) I was reminded of what a wonderful, ever-changing field astronomy is. When I first became interested in the subject in the 1960s I 'knew' that the Moon was a dry cratered dead world; I also 'knew' that Venus was a water world, probably teaming with life. I still find every new discovery completely exhilarating: despite all our knowledge there is still so much to wonder about in astronomy. I now 'know' very little about the subject, despite knowing so much more than when I 'knew' so much! But I still have a sense of wonder when I think of whether, in the coming years, we'll discover that Mercury was a gas giant whose atmosphere boiled off and delivered the atmospheric gases and water to Venus, Earth and Mars. Or will we find that Uranus is in fact a captured rogue planet that's been warming up for the last 4.5 million years?

Astronomy has given me 50 years of pleasure, yet it looks like the next 20 years could be even better. I look forward to the findings from Dawn, New Horizons, Rosetta (and hopefully Philae), JWST, ALMA, and Juno. And I look forward to a time when we can have streamed data direct from the probes, orbiters and rovers around the Solar System.

George Futers, Peebles

Put it like that, George, and this passion of ours is pretty incredible, isn't it? It's enough to send shivers up your spine! ***– Ed***

OOPS!

In the March issue's *Stargazing LIVE 2015* episode guide (page 33) the transmission date of episode four was incorrect. It should have read 20 March.

The perfect addition to your stargazing, *BBC Sky at Night Magazine* is your practical guide to astronomy, helping you to discover the night skies, understand the Universe around us and learn exciting techniques for using your telescope.

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Sky at Night MAGAZINE

Hotshots

This month's pick of your very best astrophotos

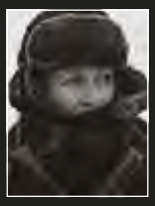
▼The Northern Lights

DAN BARTLEY, ABISKO, NORWAY, 12 JANUARY 2015

Dan says: "This was a first-time aurora hunt for me and my mother, and quite simply it was the most incredibly magical experience of my life. This image was created using three shots from two different cameras – a Nikon DSLR supplied by our tour organiser and my own Canon. I shot 20-second exposures at ISO 1600 on the Nikon, and 20-second exposures at ISO 800 on the Canon."

Equipment: Canon EOS 600D and Nikon D3200 DSLR cameras.

***BBC Sky at Night Magazine* says:** "We love the composition of this picture, with the remote villages of northern Norway in the foreground showing how close to home the stunning aurora above really is."



About Dan: "I became interested in astrophotography when I saw a friend's picture of Saturn. That reawakened a childhood dream. After being given a camera by my mother, who's a professional photographer, I started pointing and shooting! I'm particularly fascinated by nebulae."

PHOTO OF THE MONTH

The Heart Nebula ▶

GAVIN JAMES, MARLBOROUGH, WILTSHIRE
16 JANUARY 2015

Gavin says: "Fitting the entire target in the frame was too much of a squeeze, so I embarked on my first mosaic. I'm very happy with the result. It shows delicate detail in the nebulosity and the colour has come out as a gloriously dark and moody shade of red."

Equipment: QSI 683wsg CCD camera, Sky-Watcher 80ED telescope.

▲ Colour-saturated Moon

SCOTT PHILLIPS, LLANELLI, SOUTH WALES, 28 JANUARY 2015

Scott says: "I wanted to edit my Moon shots a little differently and came across a stunning colour-saturated full Moon picture online, so decided to try this approach out on my waxing crescent shot."

Equipment: Olympus E-450 camera with T-ring, Sky-Watcher Explorer 130 EQ2 telescope, 13 per cent Moon filter.

▼ Star trails

JOHN RUDDY, FARNLEY, NORTH YORKSHIRE
6 DECEMBER 2014

John says: "I'm just starting out in astro imaging. I finally had a clear weekend night to get my scope out, only to be thwarted by a very bright, almost full Moon. I was about to give up and head back in when I thought I'd have a go at a star trail, just to get something captured. I think it turned out okay, and the Moon lit up the foreground building!"

Equipment: Canon EOS M DSLR camera, EF-M 22mm f/2 STM lens, fixed tripod.

◀ The Pleiades

CHRIS HEAPY, MACCLESFIELD, CHESHIRE
1 FEBRUARY 2015

Chris says: "The Pleiades is everyone's favourite star cluster thanks to its beautiful young blue stars, and with longer exposures like this one the surrounding blue reflection nebula is revealed. Of particular note here is the nebula surrounding Merope (the bright, lower star in this image) where the hints of colour indicate the dusty nature of emission nebulae."

Equipment: Atik 490EX CCD camera, Tele Vue NP127is refractor, Losmandy mount.

▲ The Veil Nebula

HAIM HULI, ISRAEL, 8 NOVEMBER 2014

Haim says: "I took this picture from my home observatory over 11 nights. Total exposure time in hydrogen-alpha was 10 hours, with another 1.5 hours in each RGB channel. The hydrogen-alpha edit was relatively easy; the struggle was with the colour of the nebula."

Equipment: QSI 583wsg mono CCD camera, Sky-Watcher P250 Newtonian with Moonlite focuser, ASA DDM60 mount, MPCC coma corrector, Astrodon Ha (3nm) and RGB filters.

▲ Solar prominences

JOHN CHUMACK, OHIO, US
5 FEBRUARY 2015

John says: "I captured this image from my backyard observatory at lunchtime. The seeing wasn't the best, but I took a shot of these prominences on the Sun's western limb anyway since we have had nothing but clouds and snow for a while. The final image comprises 740 frames, stacked using RegiStax 6."

Equipment: QHY5L-II CCD camera, Lunt 2.36-inch/50F solar scope, 2x Barlow lens.

ENTER TO WIN A PRIZE!

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We've teamed up with the Widescreen Centre to offer the winner of next month's best Hotshots image a fantastic prize. The winner will receive an Orion StarShoot Solar System Colour Imager IV camera, designed for capturing sharp shots of the Moon and planets.

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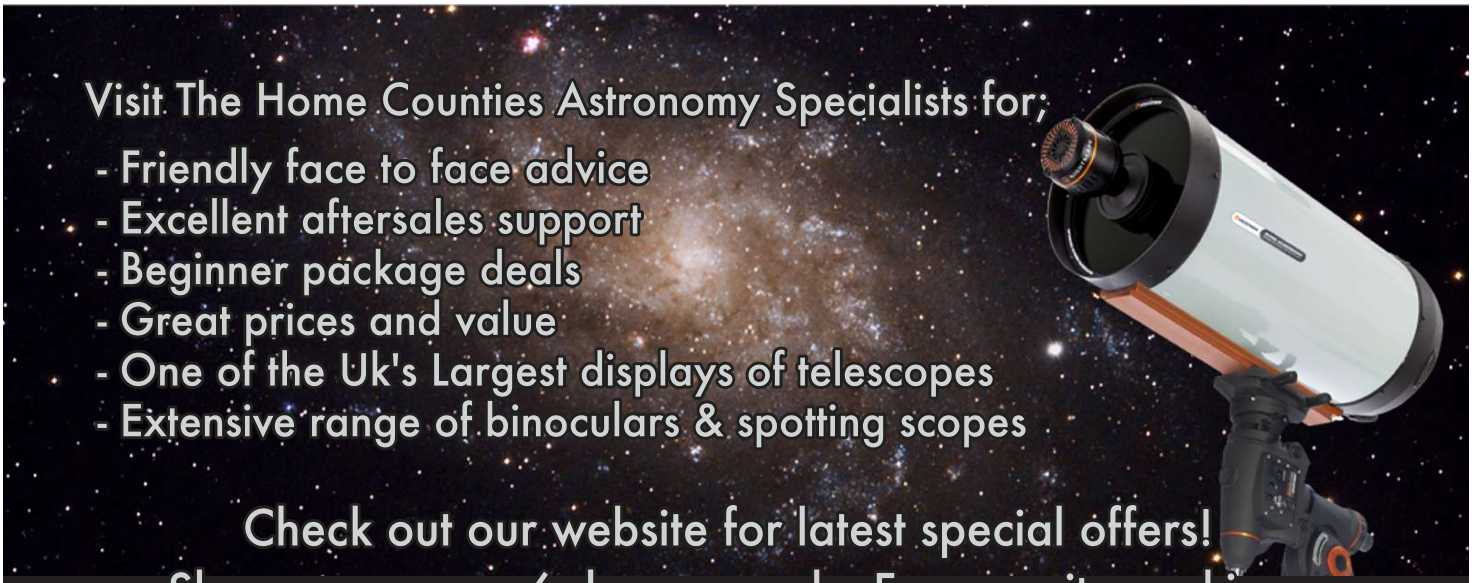

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INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

If you're inspired by the tips in this feature, why not enter your resulting images into the 2015 Insight Astronomy Photographer of the Year competition? This year there are eight categories, including one dedicated to skyscapes – the perfect shot for simple DSLR and kit lens setups. For full details of how to enter, the categories and prizes, visit www.rmg.co.uk/astrophoto.

Shots like this can be captured with simple equipment; turn the page to find out how

Widen your horizons

Will Gater looks at the attraction of the humble DSLR and kit lens for wide-field astrophotography

Have you ever been on holiday looking up at a spectacular night sky and thought 'wow, I'd love to get a picture of this'? Or maybe you've been on a walk or camping trip in a remote area and wanted to photograph the glowing Milky Way or a picturesque nightscape. Chances are that any weighty tracking mount, telescope or CCD you own was sitting safely at home; but what about a trusty DSLR and photographic tripod? This lightweight setup is remarkably versatile, and even if you're an experienced imager in other areas you may be surprised at what you can achieve with it. In this feature we'll look at how this equipment, coupled with a basic wide lens, can be used to capture the night sky. ▸

A BASIC WIDE-FIELD SETUP

THE DSLR

At a minimum your DSLR should have the ability to hold its shutter open for 30 seconds and preferably have a 'bulb' setting to go even longer. Make sure you familiarise yourself with how to manually set the ISO sensitivity, exposure and lens aperture before you head out.

TRIPOD

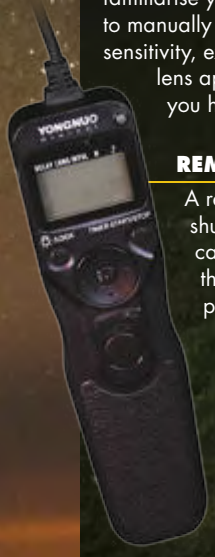
A photographic tripod is vital to keep your camera steady. Check it is sturdy enough to make it worth using: you want one that can comfortably hold the weight of your DSLR, doesn't flex substantially and has a head that locks securely.

THE LENS

The modern kit lenses of most DSLRs are perfectly capable of taking great wide-field images. Fast, wide-angle lenses are also great for sweeping vistas, and because they are so wide you can get away with longer exposures.

REMOTE RELEASE

A remote release allows you to fire the DSLR's shutter without touching the camera, which could cause vibrations and ruin your shot. Releases that allow you to lock the button down are particularly handy for star trail shots.



KARABINER

If the centre column of your tripod doesn't have a hook, a karabiner – of the kind often found in camping stores – is useful for attaching your rucksack (see left). It'll also allow for quick release if you need to move the tripod.

RUCKSACK

A rucksack with a few heavy items – such as stones – inside can weigh down and steady your tripod. The rucksack should be well secured and touching the ground (so it doesn't swing), and balanced so that it won't pull over the tripod over.

ALL PICTURES: WILL GATER

The flexibility of DSLRs, not to mention the fact that many people have them before they get into astronomy, means that they are a great starting point for budding astrophotographers. Combined with a cheap photographic tripod, a DSLR can produce attractive nightscape images of planetary conjunctions, constellations and moonrises as well as atmospheric phenomena. And – as we've outlined on the opposite page – there are several celestial sights that really lend themselves to being photographed with this simple setup. The main advantage that a DSLR offers over a compact digital camera is that its shutter can be left open for an extended period; in astrophotography this can be anywhere from a few seconds, for bright twilight nightscape scenes, to 30 seconds or more for a shot of star trails or the Milky Way. DSLRs also tend to produce cleaner, less 'noisy', images than compact cameras and – generally – they are much more sensitive. In this feature we're going to be focusing mainly on using a DSLR on a static photographic tripod. While fast, more expensive, wide-angle lenses work really well for this kind of astrophotography, we'll assume that you're using a standard kit lens, such as the 18-55mm that sometimes comes with Canon's beginner DSLRs.

Let's look first at how to take a basic nightscape shot. With your camera secured on its tripod, arrange and focus your shot in the viewfinder.

▲ ► Shooting nightscapes offers the chance to capture events such as conjunctions (above) and moonrises (right) in an Earthly context

WILL GATER X 6, ISTOCK

CALCULATE YOUR SKY COVERAGE

If you're wondering which celestial targets will fit nicely in your camera's field of view, free planetarium program Stellarium (**www.stellarium.org**) has a built-in field of view plugin that can show you the area of sky your camera/lens combination covers.

Some modern DSLRs have a live view function that makes focusing on a star using the rear screen very easy. If yours doesn't, the camera's autofocus can sometimes be used to focus on a very distant streetlight before moving back to your subject.

Once the view is focused and you're happy with the composition, its time to set the exposure length and ISO sensitivity on the camera. For twilight scenes – for example some bright planets setting over a horizon – a few seconds should be fine. When setting the ISO, remember that the higher the value, the noisier the image will get. Opening up the lens aperture can allow in more light, but this is sometimes at the expense of ►

BEYOND THE MILKY WAY

Wide-field astro imaging isn't just about shooting nightscapes or the Milky Way. Here are some other phenomena that can be photographed well with a DSLR and a tripod

AURORAE

If you're lucky enough to visit the Arctic Circle or see a bright auroral display from the UK, a DSLR and tripod are all you need to capture this stunning celestial sight. Keep your exposures short (no more than 10-20 seconds) to capture the details in fast-moving auroral curtains.

◀ METEORS

Meteors are hard to photograph. You need to be lucky that one passes through your camera's view, and even if it does it might not show up. On a meteor shower peak night, set the aperture of your lens fully open, use a high ISO (1600-3200) and take many exposures of around 10 seconds each.

▲ STAR TRAILS

A star trail image shows the apparent motion of the stars across the sky. Point your DSLR anywhere in the night sky (near Polaris makes for a good shot) and take at least 10-15 minutes' worth of 60-second exposures. The final image can be made with software like that found at www.startrails.de.

NOCTILUCENT CLOUDS ▶

Noctilucent – 'night shining' – clouds are an atmospheric phenomenon seen during the summer months here in the UK. Their bright, expansive, nature and intriguing structures make them ideal for DSLR photography. An exposure of a few seconds and a moderate ISO setting should pick up most displays easily.

GETTING THE SHOT

In this tutorial we'll look at how to create a wide-field image of the Milky Way with just a static tripod, wide lens and a DSLR. This process also works well on other large subjects like constellations and can even be used to capture extreme wide-field shots of comets

1 SECURE YOUR TRIPOD

First set up your static tripod. If you're out in the wilderness, check its legs aren't going to sink into mud, sand or snow. If you find the tripod wobbles in the wind, reducing the extension of the legs can sometimes help. A carefully attached rucksack (see page 33) can be used to add weight to the tripod for stability.

2 FOCUS THE LENS

One way to do this is to focus on a very distant streetlight using the camera's autofocus. If your DSLR possesses a live view screen, a simple and accurate alternative is to centre a bright star in the viewfinder, switch on the live view function and manually adjust the lens's focusing ring until you get the smallest and sharpest view of the star.

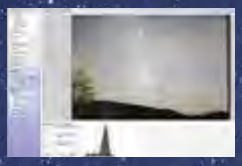
3 ADJUST YOUR SETTINGS

Set the exposure length, aperture and ISO. Take a few test shots to see what exposure length you can get away with before star trailing becomes evident. ISO and aperture settings will largely depend on your camera and what you're shooting – we've given some tips for certain targets on page 35. For the Milky Way we're going to use 30-second exposures at ISO 1600.

4 SNAP AWAY

Once you've centred your subject in the field of view – here we were shooting the central region of the Milky Way – switch your camera to continuous shooting mode and take a series of uninterrupted images. A total of five minutes' worth of individual exposures will be plenty enough to begin with.

5 ALIGN AND STACK



After you've captured your images you'll need to use stacking software to combine them; we used DeepSkyStacker (http://deepskystacker.free.fr/english/index.html). Be sure to select the hot-pixel removal option. DeepSkyStacker can also be used to calibrate your image with any dark frames you may have captured.

6 TEASE OUT THE DETAIL

Once you have an image from DeepSkyStacker that you're happy with it's best to save it as a TIFF or PNG file, then bring it into a layer-based editing program such as Photoshop or GIMP for any final tweaks. Use the Levels adjustment tool (available in most photo editing software) to brighten the image, and adjust the colour balance if necessary.

▲ A simple DSLR and tripod combo can also deliver shots of asterisms and constellations; here, the W of Cassiopeia shines brightly

▸ more distorted stars towards the edges of the field of view. The trick with nightscape photography with a DSLR and tripod, then, is to balance the detail you pick up in your image with the noisiness of the picture, the sharpness of the stars and how much the stars have trailed – we'll come to that last factor in a moment. Really the best way to find what works for your setup is to play around with different settings until you're happy with the shot.

Pinpoints no more

If your exposures are too long you'll notice that the stars, rather than being points of light, will have 'trailed' into short lines. This is because of Earth's rotation. Over the course of a night the stars all appear to slowly track across the sky and even an exposure of 30-40 seconds is enough to pick up this gradual movement. When shooting with a static tripod and DSLR, which isn't tracking the night sky on a driven mount, you have to take this into account when setting our exposure length. Otherwise our shots will be blurred in this way.

As well as watching exposure length, there are two other approaches to avoiding star trailing in your static tripod and DSLR shots. The first is to use the shortest focal length on your lens. With a shorter focal length the time it takes for trailing to become noticeable is longer and so you can get away with longer exposures. Trailing is also more evident the farther away you point your camera from the celestial poles, so one way of limiting trailing is to image the sky near to the pole star, Polaris in Ursa Minor.

What if you want to take more deep and detailed shots of constellations and the Milky Way with just a photographic tripod and DSLR? One way is to stack several short exposures – where the length of the exposure means star trailing isn't evident – together. On the page to the left we explain exactly how to do this in detail. Ideally, you'd have the DSLR and lens mounted on a tracking mount (for example, an AstroTrac, Vixen Polarie or Sky-Watcher Star Adventurer) that follows the sky as it moves. Then you could take much longer exposures without worrying about star trailing. Even so, if you don't have one of these, or are off to some remote destination, we hope we've convinced you not to leave your DSLR and tripod at home on the next clear night.

▼ Here we see how stacking several short images can help to reduce star trailing. In the top image, a crop of a 25-second shot taken at ISO 400 with a 50mm lens, the trailing is clear. The middle image is an exposure of just two seconds; stars are not trailed, but there is less detail. In the bottom image several short (and crucially, untrailed) exposures have been stacked for a good result.

DARK FRAMES

Once you've taken enough exposures to stack together, capture several 'dark frames' – these are shots taken with the same settings and conditions, but with the lens cap on. These can then be used in stacking software to reduce the noise in your final image.

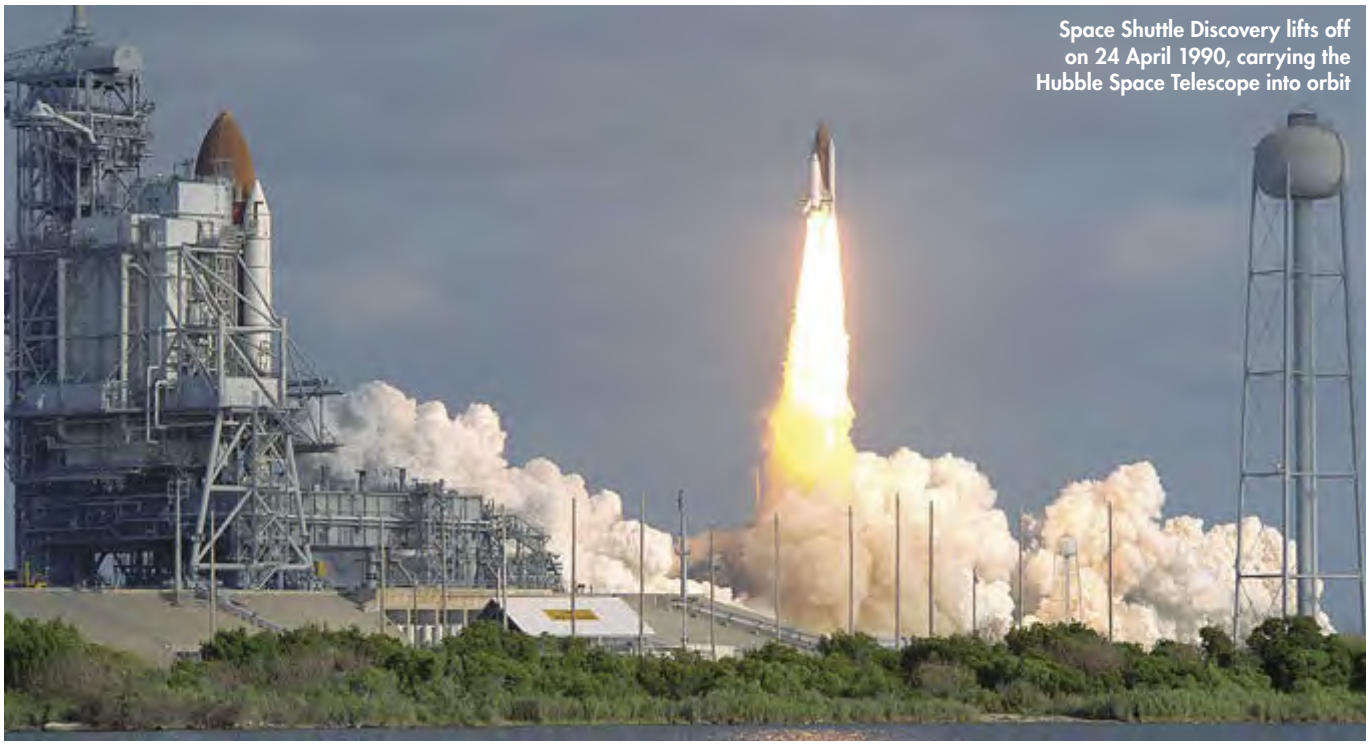
ABOUT THE WRITER

Will Gater is an astronomer, science writer and author of several popular astronomy books. He also appears on TV and radio to talk about space. Find him on Twitter: @willgater

WILL GATER X 8, ISTOCK

THE HUBBLE REVOLUTION

Elizabeth Pearson looks back at a quarter of a century of science from the Hubble Space Telescope



Space Shuttle Discovery lifts off on 24 April 1990, carrying the Hubble Space Telescope into orbit

"Hubble's most important discovery was one that no one ever saw coming – one that has revolutionised the way we look at the Universe"

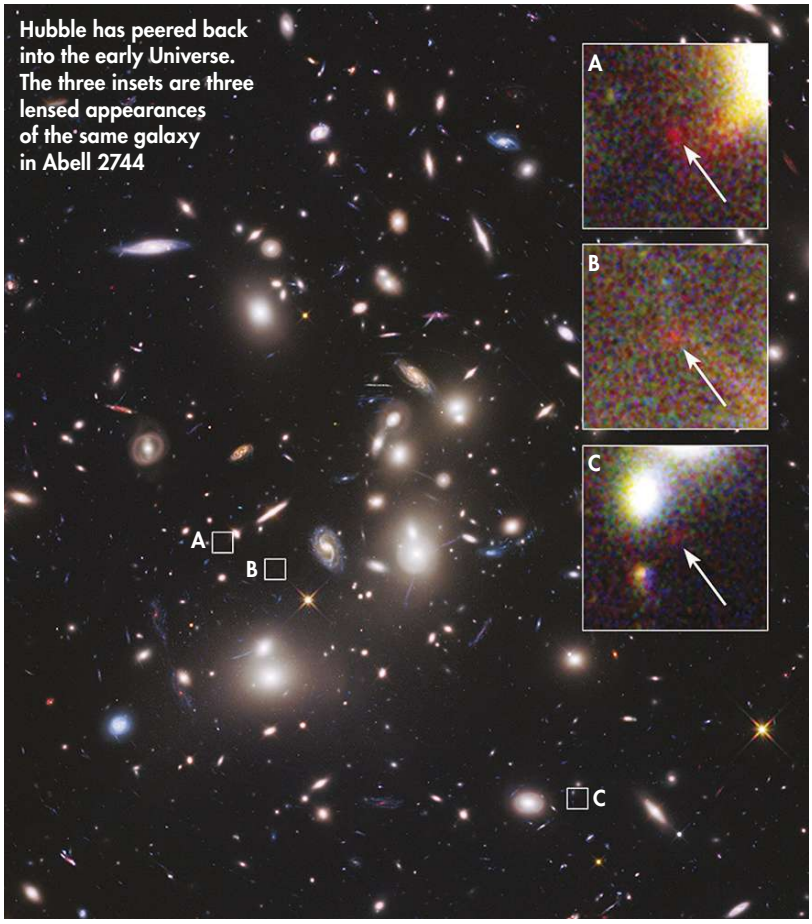
For 25 years, the Hubble Space Telescope's evocative images have inspired people all over the world, connecting them to the cosmos with views unlike any seen before. Rather than being simply a scientific instrument, it has grown to become an icon in space science.

Though there had been space observatories before Hubble, its scientific power and versatility was unparalleled, and it remains one of the best-equipped telescopes to this day. Hundreds of astronomers regularly turn to Hubble, using this highly advanced instrument to conduct surveys of the Universe that can last for years or even decades.

These constant observations have led to many discoveries over the years, and new ones are still being made a quarter of a century on. Only last year the telescope revealed one of the oldest galaxies that has ever been found. The galaxy is so far away that the light from it is over 13 billion years old.

Unexpected science

But perhaps Hubble's most important discovery was one that no one ever saw coming – one that has revolutionised the way we look at the Universe. Researchers were attempting to gauge how fast the Universe was expanding, using Hubble's precise optics to image supernovae in distant galaxies to calculate their distances, ▸



Hubble has peered back into the early Universe. The three insets are three lensed appearances of the same galaxy in Abell 2744

ISTOCK, ESA, NASA, NASA/ESA/A. ZITRIN (CALIFORNIA INSTITUTE OF TECHNOLOGY/PASADENA AND J. LOTZ/M. MOUNTAIN/A. KOEKEMOER AND THE HFF TEAM (SPACE TELESCOPE SCIENCE INSTITUTE BALTIMORE MD.)

NASA, NASA/ESA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA), NASA/ESA D. BATCHELDOR AND E. PERLMAN (FLORIDA INSTITUTE OF TECHNOLOGY), THE HUBBLE HERITAGE TEAM (STSCI/AURA) AND J. BIRETTA/W. SPARKS AND F.D. MACCHETTO (STSCI), C.R. O'DELL AND S.K. WONG (RICE UNIVERSITY) AND NASA/ESA, NASA/ESA AND P/KALAS (UNIVERSITY OF CALIFORNIA/BERKELEY), ISTOCK X 2

▲ **Spiral galaxy M100 imaged before and after Hubble's sight-saving first servicing mission in 1993. The difference in clarity is staggering**

▸ but the research showed that the Universe wasn't slowing down as expected. It was speeding up. To explain this phenomenon, researchers had to introduce an unknown force that is driving galaxies apart: dark energy.

"Hubble rewrote the astronomy book," says Antonella Nota, ESA's Hubble project scientist. Nota has been with the telescope for over 30 years, and has seen the project through some toil and trouble. After funding crises threatened to scupper Hubble before it ever flew, ESA joined what had hitherto been a NASA project to shoulder the financial burden, as well as provide instruments and staff. When Nota joined in 1986, the telescope was ready to launch.

"The excitement was incredible, we were due to launch on the next shuttle," says Nota. "But in January I was sitting in the auditorium when Challenger exploded in front of our eyes."

The tragedy halted Space Shuttle traffic for almost three years but, after a thorough investigation, they resumed. Hubble was eventually launched on Discovery in 1990. "Everybody was looking forward to the spectacular images," says Nota. "That's when the spherical aberration hit."

Because of an error in production, the curvature of the space telescope's 2.4m mirror was out by 4µm. This is only 1/50th the width of a human hair, but it was enough to prevent light from focusing properly. The world's greatest telescope was all but useless.

"At first people couldn't believe their eyes," says Nota. "Every time one of those images appeared on our screen you could see in people's expressions ▸

HUBBLE IN NUMBERS

13.3m
The length of the Hubble Space Telescope

28,000km/h
The speed Hubble orbits the Earth

844GB
The quantity of data Hubble produces per month

1 million
The number of observations made to date

560km
The altitude at which Hubble orbits the Earth

2.4m
The diameter of Hubble's primary mirror

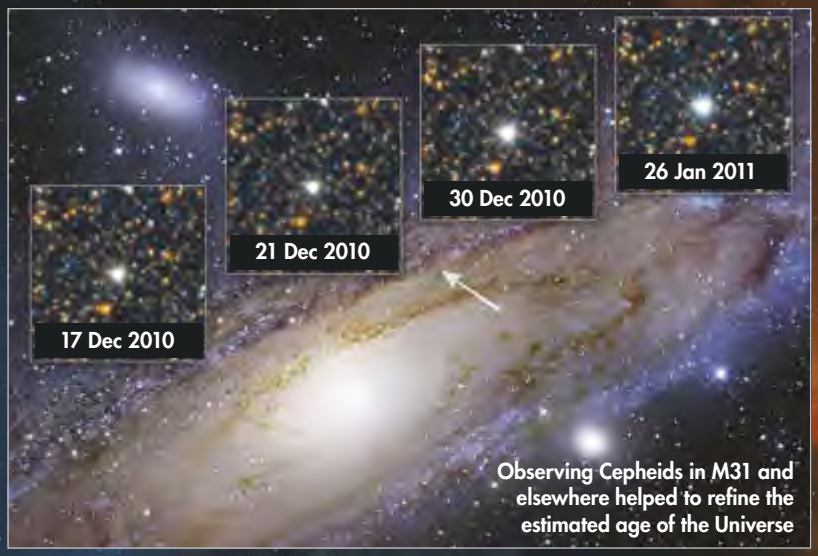
38,000
The number of individual celestial targets Hubble has observed

11,000
The number of published scientific papers that have used Hubble data

11,113kg
The weight of the telescope, as much as two fully grown Asian elephants

GREAT DISCOVERIES

Hubble has played a critical role in some of the major astronomical finds of recent years



Observing Cepheids in M31 and elsewhere helped to refine the estimated age of the Universe

THE AGE OF THE UNIVERSE

The Universe has been expanding since the Big Bang, but how long has that been? The age of the Universe is one of the fundamental questions of cosmology, but before the Hubble Space Telescope it was only known to be somewhere between 10 and 20 billion years old. In order to measure the Universe's age, astronomers had to measure how quickly it was expanding, a value known as the Hubble constant.

This is where the Hubble Space Telescope came in. The telescope surveyed Cepheid variable stars in various galaxies. These stars pulse in a way that lets scientists calculate their brightness very precisely, and so measure the distance to the galaxy containing that star. By measuring 31 Cepheid variables in distant galaxies it could determine the rate of expansion to an accuracy of five per cent, giving the age of the Universe as around 13.7 billion years. This has since been refined to 13.8 billion years.

The black hole powered jets of M87, where Hubble found its first supermassive monster

SUPERMASSIVE BLACK HOLES

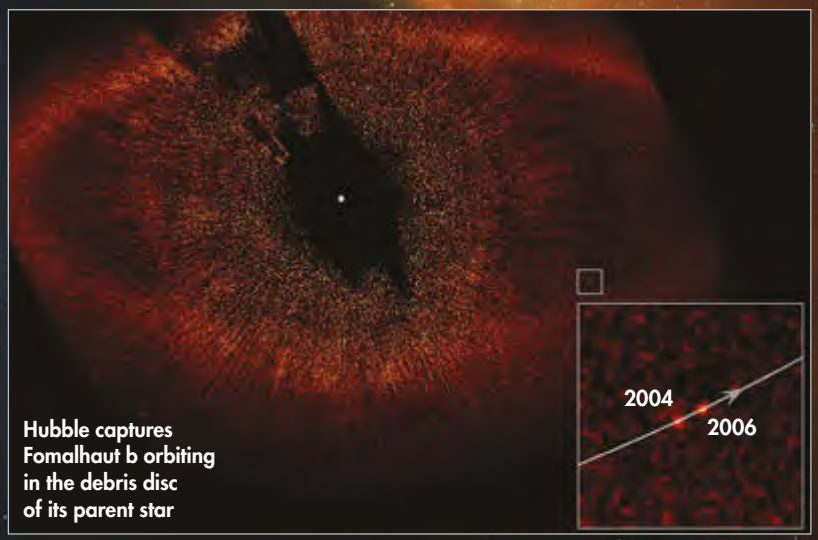
In 1990, there was speculation that a huge mass several billion times that of the Sun, known as a supermassive black hole, lay at the centre of most galaxies, but there was no proof. Hubble would change that. "What Hubble found was that at the centre of galaxies, the gas on one side was moving away from us very fast and the gas on the other side was moving towards just as quickly," says NASA Hubble project scientist Jennifer Wiseman. "The only thing that could be holding that gas in orbit at such high velocities was a huge amount of mass compressed into a small volume. In short, a supermassive black hole." The first galaxy that Hubble found such a mass in was the galaxy M87, but it wasn't long before more supermassive black holes were found.

The space scope discovered a group of 50 brown dwarfs in the Orion Nebula

THE BIRTH AND DEATH OF STARS

The environment in which stars form has a huge role in what type of stars they will go on to become. "Stars tend to grow fastest in groups and clusters, and the biggest stars form fastest," says Wiseman. "These big stars then consume the surrounding gas, making it harder for subsequent stars to form. Hubble helped us to understand how in a dynamic environment stars form and then affect their environment."

Being able to see the intricacies of these gas clouds in nebulae such as Orion is vital to understanding how stars form. "Hubble has helped us because of its sensitivity and sharp angular resolution," says Wiseman. "You can resolve individual stars and their environments."



Hubble captures Fomalhaut b orbiting in the debris disc of its parent star

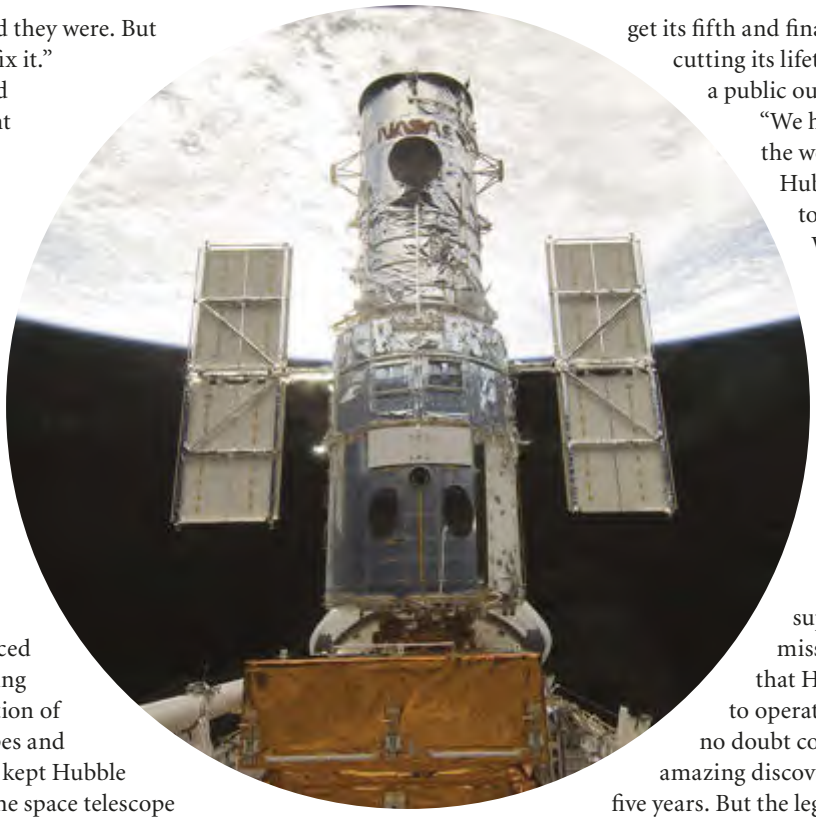
EXOPLANETS

When Hubble launched, there were no known exoplanets. Now there are over 1,000 confirmed alien worlds. "Hubble transformed our understanding of how stars and planets form," says Wiseman. "It was one of the first telescopes that saw all stars seem to form surrounded by discs of dusty debris. It's in those regions that planets are born." But simply finding planets is no longer enough. Astronomers want to categorise them, looking at their atmospheres to see what the environment is like on exoplanets. Hubble was also the first telescope to detect the presence of specific elements in the atmospheres of exoplanets.

▸ how disappointed and sad they were. But there was also a resolve to fix it."

What saved Hubble – and what would go on to cement its place as one of the most scientifically prolific astronomical instruments of all time – was its ability to be upgraded. The first servicing mission installed a new camera, the Wide Field and Planetary Camera 2, which compensated for the spherical aberration and allowed scientists to take full advantage of the telescope's powerful optics. In the years that followed, Hubble was serviced a further four times, allowing for repairs and the installation of new instruments, gyroscopes and batteries. Not only has this kept Hubble in peak condition, it kept the space telescope outfitted with the best equipment of the time.

"Every time the astronauts went there, they left a completely new observatory," says Jennifer Wiseman, NASA's Hubble project scientist. "After 25 years, Hubble is operating at the peak of its scientific performance right now."



▲ **Hubble berthed to Space Shuttle Atlantis during its final servicing mission in 2009; these upgrades will keep the telescope going until 2020**

A cultural icon

As well as conducting scientific observations, Hubble regularly takes incredibly detailed images that are then released to the public. Today, you can see these images everywhere, from postage stamps to t-shirts and cinema screens. And when it appeared that Hubble wouldn't get its fifth and final servicing mission, cutting its lifetime short, there was a public outcry.

"We had people all around the world rallying for the Hubble Space Telescope to be maintained," says Wiseman. "It shows how popular this observatory has become. People appreciate having their sights and their spirits lifted above the mundane of everyday life, and seeing that we are part of a magnificent Universe."

With the public's support, the final servicing mission in 2009 ensured that Hubble could continue to operate until 2020, and will no doubt continue to deliver amazing discoveries for its remaining five years. But the legacy of Hubble goes far beyond the mere science it has done. Students are pursuing careers in astronomy today because of the images they saw as children and the iconic pictures will be a part of popular culture for years to come.

"Hubble is the people's telescope," says Nota. "It belongs to everybody."

NASA, ISTOCK, NORTHROP GRUMMAN

ABOUT THE WRITER

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s staff writer, specialising in space science. She gained her PhD in extragalactic astronomy at Cardiff University.

HUBBLE'S SUCCESSOR

Though Hubble will be functional for another five years, NASA has been busy working on its successor, the James Webb Space Telescope (JWST). However, the JWST will not simply be Hubble 2.0. Rather than building another bigger, better optical telescope, NASA is working on the largest infrared space telescope ever conceived.

"To look back at the early Universe you really need to look in the infrared," says NASA Hubble programme scientist Michael Garcia. "Hubble doesn't have that capability. The JWST will continue the work that Hubble is doing."

By observing in the infrared, the JWST will be able to see further than Hubble ever can. Not only can infrared radiation pierce through clouds of dust that blocks most visible light, it also allows the telescope to detect galaxies so far away they have been redshifted out of the visible spectrum.

"We hope that it will make the same kind of impact that Hubble has made," says Garcia. "We hope to build on that reputation."

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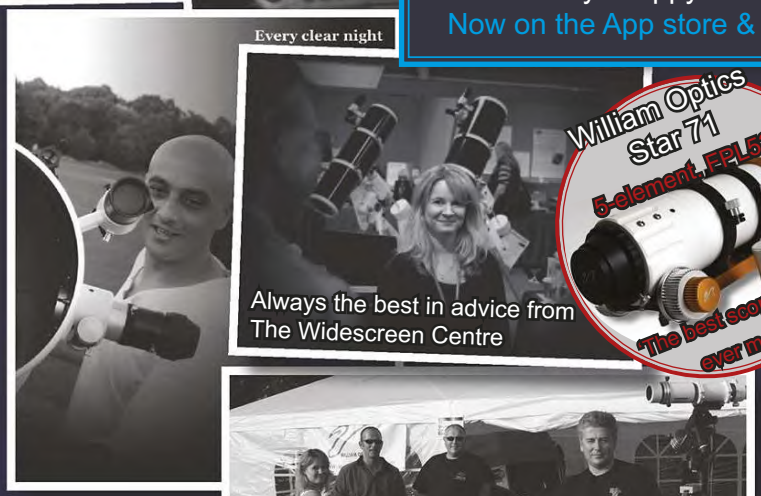

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Lunar photo by Widescreen customer Richard Maun. Main BSIA image by Tom Kerss. Sadr nebulosity by Geoffrey Lenox-Smith

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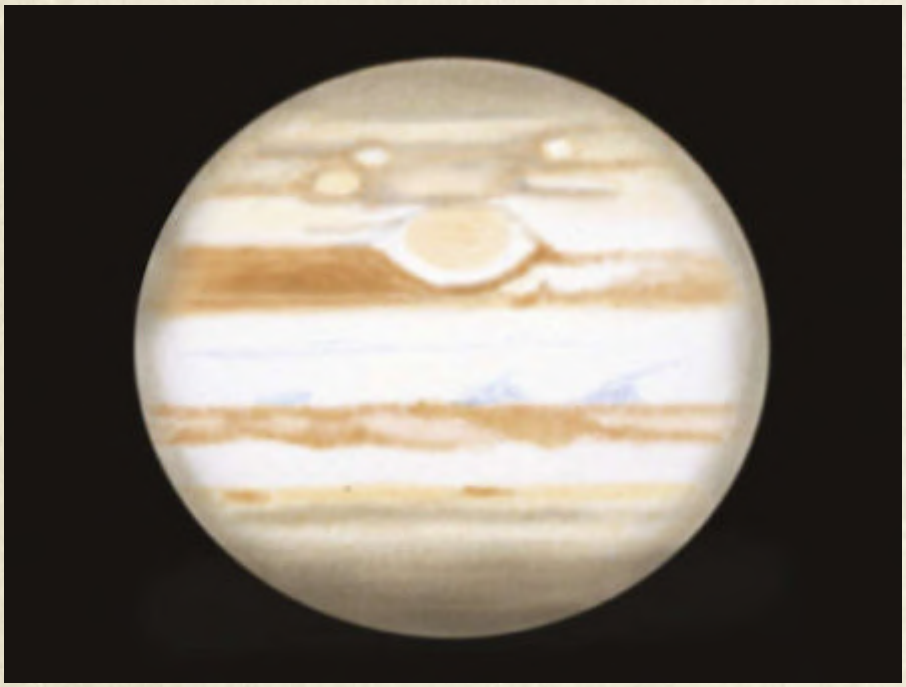
Drawn to Jupiter

Sketching is an important skill for any visual observer. Here, **Paul Abel** shows us how to make a drawing of Jupiter



▲ Jupiter's disc offers a wealth of detail, making it a great target for building your sketching skills

PAUL ABEL X 5, ISTOCK X 3

The eternally shifting clouds of Jupiter provide great training for visual observers. On a good night, a stunning amount of detail is revealed: dark storms in the belts, delicate festoons in the equatorial zone and enormous swirling cyclones in the temperate regions. For this reason, drawing Jupiter can be a daunting task. Not only is there a great deal to be seen on an average night, but the planet rotates very quickly: a day on Jupiter is less than 10 hours long. There are, however, a few things you can do to maximise your Jupiter observations and obtain an accurate drawing.

There are several essential things you should prepare before you head out to the telescope. First, you'll need some accurate Jupiter blanks. Jupiter is appreciably flattened and so a circular template won't do. The standard Jupiter blank has a diameter of 64mm and a height of 60mm. Have a few ready to take outside.

You'll also need a selection of pencils: some features, such as the equatorial belts, are dark and require a 3B-4B pencil, while the festoons are much more delicate and require a B pencil. An eraser and pencil sharpener are also very useful. Finally, you'll need a red light to preserve your night vision – for many years I managed with a normal torch that I had painted red with acrylic paint.

At the telescope

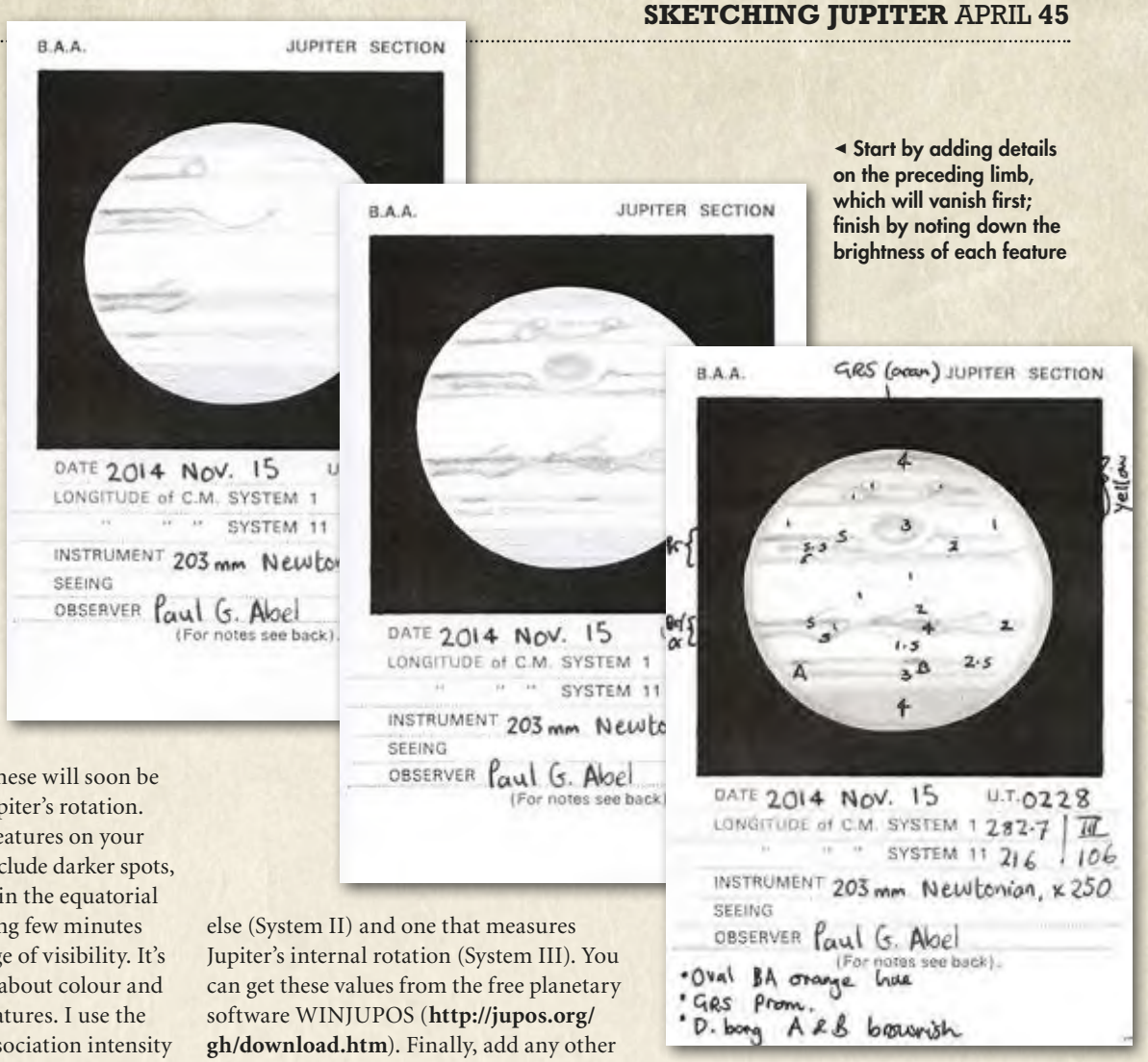
Once outside, the first task is to get the magnification right. Jupiter does not tolerate high magnification – I normally use 165x-250x. If the seeing is poor, you'll need to find the lowest usable magnification, with which the image is still large enough for you to see the storms in the belts and zones.

You'll need to spend some time looking at Jupiter before you notice all of its finer features. Spend about 15 minutes examining the planet, building up a picture in your mind. Filters are really helpful here: a W#11 (yellow) is an excellent all-round filter for Jupiter, bringing out details in the belts and zones. A W#25A (red) filter is good for enhancing bluish features such as festoons

in the equatorial zone, while a light blue W#80A filter will increase the contrast of reddish features such as the belts and the Great Red Spot.

After this time has elapsed, you can start your sketch. Spend the first two or three minutes drawing in the main equatorial belts using a 3B or 4B pencil. Next, add in any other fainter belts you can see, along with the polar shadings.

Now spend six minutes putting in the finer details. Draw in objects near the preceding limb first, as these will soon be carried off the disc by Jupiter's rotation. Place the most obvious features on your blank first – these may include darker spots, bright rifts and festoons in the equatorial zone. Spend the remaining few minutes adding details on the edge of visibility. It's a good idea to add notes about colour and brightness for various features. I use the British Astronomical Association intensity scale from 0 (very bright) to 10 (black sky).



◀ **Start by adding details on the preceding limb, which will vanish first; finish by noting down the brightness of each feature**

Take note

Jupiter's swift rotation means that new features are always coming onto the disc. Even after one hour it will become obvious that the planet has changed a great deal. For a long Jupiter session, you should aim to make a disc drawing once an hour to capture the new details and show how they evolve.

Copy up as soon as you can. The most important task is to make a neat version of your drawing – this can be done either in black and white or colour, but its best to do it as soon as possible after you finish your observing session so it remains fresh in your mind. I personally prefer to make colour drawings – easily done using crayons for the colours and indian inks for the shadows, with the drawings and notes made at the telescope for reference.

Any sketch should include details of the date it was made, the start and end time (in UT) of your observing session, along with the telescope, magnification and filters used, and the seeing conditions. For Jupiter you should also record the values of the longitude; the planet has three longitude systems, one for features on the equator (System I), another for features everywhere else (System II) and one that measures Jupiter's internal rotation (System III). You can get these values from the free planetary software WINJUPOS (**http://jupos.org/gh/download.htm**). Finally, add any other comments or details you think important.

It won't take long to fill up a notebook, and you'll be able to look back and see how your observational and a drafting skills have developed. No matter how experienced you become, Jupiter will always be an excellent target to help keep your eyes sharp.

ABOUT THE WRITER

Dr Paul Abel is an astronomer based at the University of Leicester. You can listen to him on our Virtual Planetarium each month.

Equipment

The following equipment is essential for drawing Jupiter:

- Plenty of Jupiter blanks at the correct size (64x60mm)
- Pencils ranging from B to 6B
- A clipboard
- A red light so you can see to draw
- A selection of eyepieces, to give you a choice of different magnifications
- Some filters, ideally W#11 (yellow), W#25A (red) and W#80A (blue)
- A notebook for your observations – don't skimp as cheap ones soon fall to bits. It needs to have a hard cover, good quality paper and be well bound
- Pencil sharpener and eraser
- WINJUPOS software

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HOW TO ENTER

To be in with a chance of receiving one of these unique First Day Covers, go to skyatnightmagazine.com/firstdaycovers, enter the access code **eclipse2015** and fill in your details on the subsequent form.

Terms and conditions: Prize is 10x Solar Eclipse Special Covers and 10x Dark Sky Discovery First Day Covers. Promoter is Immediate Media Company Bristol Limited. Offer closes 16 April 2015. Entrants must not be employees of the Promoter or Isle of Man Post Office. Entrants will receive an email confirming registration details after registration. The winners will be selected at random. Only one entry per person per competition. Entrants' details will be used in accordance with Immediate's Privacy Policy: http://www.immediate.co.uk/privacy-policy/. No responsibility accepted for lost, delayed, ineligible or fraudulent entries. The winners will be notified within 14 days of the close of the promotion. The draw is final and no correspondence will be entered into. Promoter reserves the right to substitute the prize with one of the same or greater value but there is no cash alternative. This promotion is subject to the laws of England.

The Sky Guide April

The brilliant planet Venus will pass close to the iconic and always beautiful Pleiades open cluster this month. As the sky begins to darken towards the west, the pair will look stunning visually. For those with a camera, this is an opportunity not to be missed!

Written by Pete Lawrence

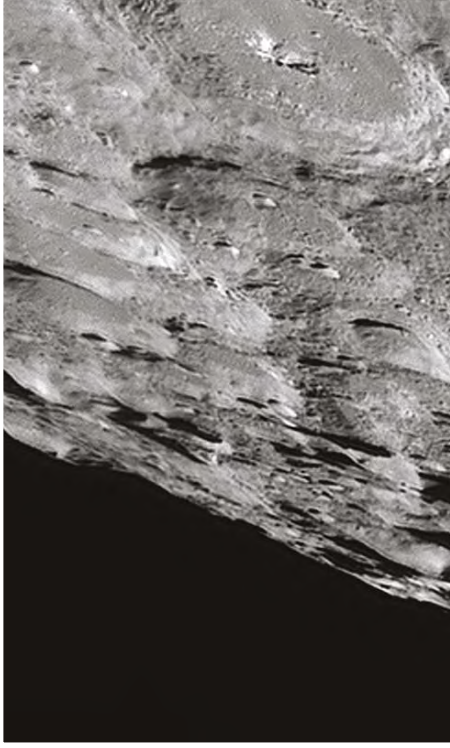
Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

PETE LAWRENCE

Highlights

Your guide to the night sky this month

This icon indicates a good photo opportunity



3 FRIDAY ▶
The star 4° above and left of the Moon this evening is mag. +2.7 Porrima (Gamma (γ) Virginis). The components of this binary were too close to separate a few years ago. Now, they're farther apart – have a go and see if you can split them with a 3-inch scope.

7 TUESDAY ▶
The Moon's south pole is well presented from 7-13 April. This is a complicated region of the lunar globe, heavily covered in craters.

Ganymede's giant shadow crosses Jupiter's disc from 22:01 BST (21:01 UT) tonight until 01:38 BST (00:38 UT) on the 8th.

8 WEDNESDAY
This morning's 87%-lit waning gibbous Moon is just over 5° west of mag. +0.6 Saturn. Both are due south at around 04:20 BST (03:20 UT).

Europa will annularly occult Callisto between 22:54:04 and 22:59:47 BST (21:54:04 and 21:59:47 UT).

9 ◀ THURSDAY
Mag. –3.9 Venus passes south of the Pleiades open cluster this month. The closest approach is on 11 April, but the planet and cluster can be seen near to each other from tonight until the 13th.

14 TUESDAY
The eastward movement of Venus now takes it to a position where it lies between the Pleiades and Hyades open clusters.

15 WEDNESDAY
Ganymede transits Jupiter between 21:10 BST (20:10 UT) on the 14th and 00:46 BST this morning (23:46 UT on the 14th). The moon's shadow follows between 02:01 and 05:38 BST (01:01 and 04:38 UT).

17 FRIDAY
This evening it is Callisto's shadow that can be seen crossing Jupiter's disc. The shadow starts to pass across the planet's eastern limb at 22:15 BST (21:15 UT) and remains visible until 02:57 BST (01:57 UT) on the 18th.

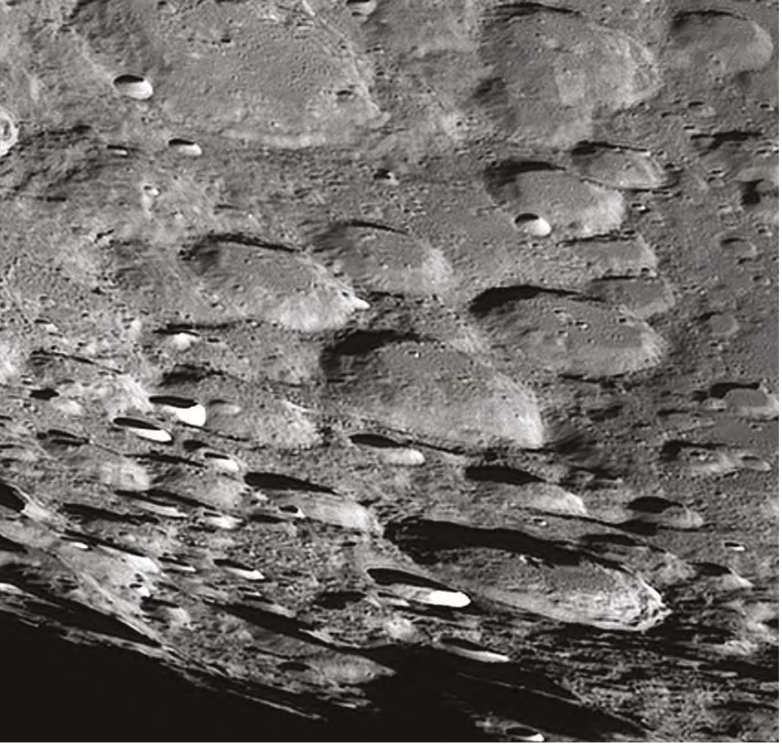
18 SATURDAY ▶
A rare annular occultation of Ganymede by Callisto occurs this morning between 02:28:05 and 02:36:55 BST (01:28:05 and 01:36:55 UT). Callisto's disc will be in front of but not quite covering Ganymede's at 02:32:30 BST (01:32:30 UT).

21 TUESDAY
The 11%-lit waxing crescent Moon lies just over 1° to the east of mag. +0.8 Aldebaran (Alpha (α) Tauri) as the sky darkens. More noticeable will be brilliant Venus, 7.25° north of the Moon. See page 50.

22 ◀ WEDNESDAY
Mag. +1.4 Mars and mag. –1.1 Mercury are 1.25° apart low in the west-northwest, shortly after sunset. See page 51.

The April Lyrid meteor shower peaks tonight and the Moon won't spoil the show. See page 51.

PETE LAWRENCE X 6



10 FRIDAY
The Moon's largely out of the way or below the horizon for a bit, making from now until the 26th an excellent time to take our *Deep-sky tour*. See page 56.

11 SATURDAY
Venus is at its closest to the Pleiades, a fraction over 2.5° south of the cluster. Look for them low down in the west as the sky darkens.

16 THURSDAY ▶
The famous Sombrero Galaxy in Virgo, M104, is due south at just after midnight. It is quite a low object from the UK; when due south it will be at its highest point in the sky.

19 SUNDAY
Mercury is visible shortly after sunset in the west-northwest. Look carefully: the delicate crescent Moon, Mercury and Mars form an equilateral triangle with the Red Planet at the top.

20 MONDAY
The Plough asterism lies overhead at midnight, making this a great time to investigate some of the deep-sky objects nearby. These include the Owl Nebula, galaxy pair M81 and M82, and of course that beautiful multiple star system Mizar and Alcor.

25 SATURDAY
Look at the Moon through a telescope at around 00:35 BST (23:35 UT on the 24th) and you'll see its dark edge occult two stars: mag. +6.6 TYC1360-1431-1 first, then mag. +5.3 68 Geminorum a couple of minutes later.

30 THURSDAY
Mercury performs a pass of the Pleiades similar to that of Venus earlier in the month. However, the conditions aren't as favourable: the pair will be low, close to the northwest horizon as the sky darkens. Mercury is mag. –0.3.

What the team will be observing in April

Pete Lawrence "The Moon, Venus, Pleiades and Hyades are a winning combination and I'll be trying to get a shot of them all together. Stopping my lens aperture down a bit should allow me to get some dramatic starburst effects."

Paul Money "I'm looking forward to the innermost planet, Mercury, returning to the evening sky this month; it's due for an exciting close encounter with Mars in the bright twilight on the 22nd."

Chris Bramley "I'm keen to focus on some deep-sky objects this month – in particular the Whirlpool Galaxy, M51, and the Black Eye Galaxy, M64."

Need to know

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

HOW TO TELL WHAT EQUIPMENT YOU'LL NEED

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

BINOCULARS
10x50 recommended

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

SMALL/MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

Getting started in astronomy

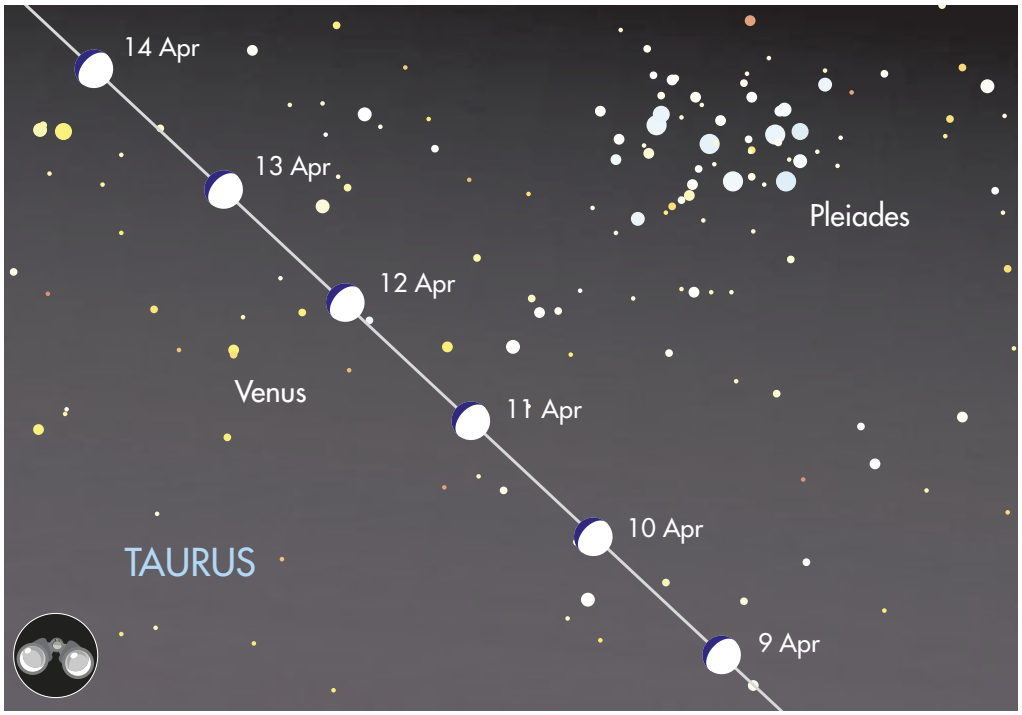
If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing your first scope.

DON'T MISS...

3 top sights

Venus meets the Pleiades and the Moon

WHEN: Venus and the Pleiades, 7-15 April; Venus and the Moon, 20-22 April



Venus zips south of the Pleiades open cluster mid-month, making its closest approach on the 11th

THE SIGHT OF Venus in a twilight sky is always rather moving. The planet's sheer brilliance is mesmerising and a joy to behold. This experience is increased when there's something equally beautiful nearby, such as a crescent Moon.

With Venus now in the evening sky, visible shortly after sunset, there must be a couple of nights each month when the waxing crescent Moon lies nearby. During April, these are the 20th, 21st and 22nd. On the 20th, a 5%-lit waxing lunar crescent sits 14° below mag. –4.0 Venus over in the western part of the sky. The following evening, the Moon will appear just 7° below and left of Venus and its phase will have increased to 12% lit. This particular evening provides a great photographic opportunity because the Moon will also be very close to the Hyades open cluster in Taurus, lying just 1.5° to the east of mag. +0.8 Aldebaran (Alpha (α) Tauri) as darkness falls.

As an aside, if you're able to locate the Moon earlier in the day – around 18:40 BST (17:40 UT) to be precise – it may be possible to spot Aldebaran just below the Moon's southern cusp. You'll need a telescope to see the star. From the centre of the UK, Aldebaran will be 3 arcminutes – that's one-tenth of the apparent diameter of the Moon – below the lunar limb.

On the 22nd, the now 20%-lit crescent will be 14° to the left of Venus as darkness falls. Over all three evenings the Moon's dark portion should be faintly visible due to earthshine and further enhancing the view.

Earlier in the month, Venus passes to the south of the beautiful Pleiades open cluster, designated M45 and also known as the Seven Sisters. There's something quite enchanting about seeing the brilliant diamond of the planet blazing away against the delicate cluster stars.

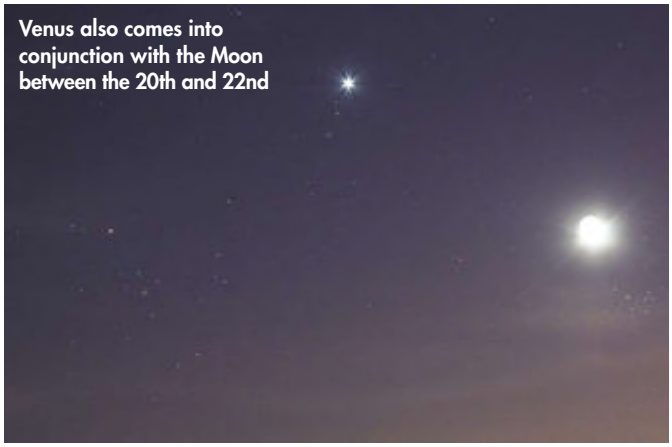
This encounter can be seen from 7-15 April, with the closest approach on the 11th, when Venus will lie 2.5° to the south of the cluster. From the UK this means that the cluster will appear above and right of the planet.

Both objects should fit in the field of view of a pair of 7x50 binoculars throughout the period of 7-15 April, and this is a great way to view the apparent close encounter. Of course, in real terms it's also quite a sobering realisation that the cluster stars lie 25 million times farther away from Earth than Venus does.

If you fancy trying to take a photograph of the meetings described here, turn to page 60 for some techniques which will help you to succeed.

NEED TO KNOW

An object's brightness is given by its magnitude. The lower the number, the brighter the object: with the naked eye you can see down to mag. +6.0.



Venus also comes into conjunction with the Moon between the 20th and 22nd

PETE LAWRENCE X4

The April Lyrids

WHEN: 16-25 April; peak activity on the night of 22/23 April

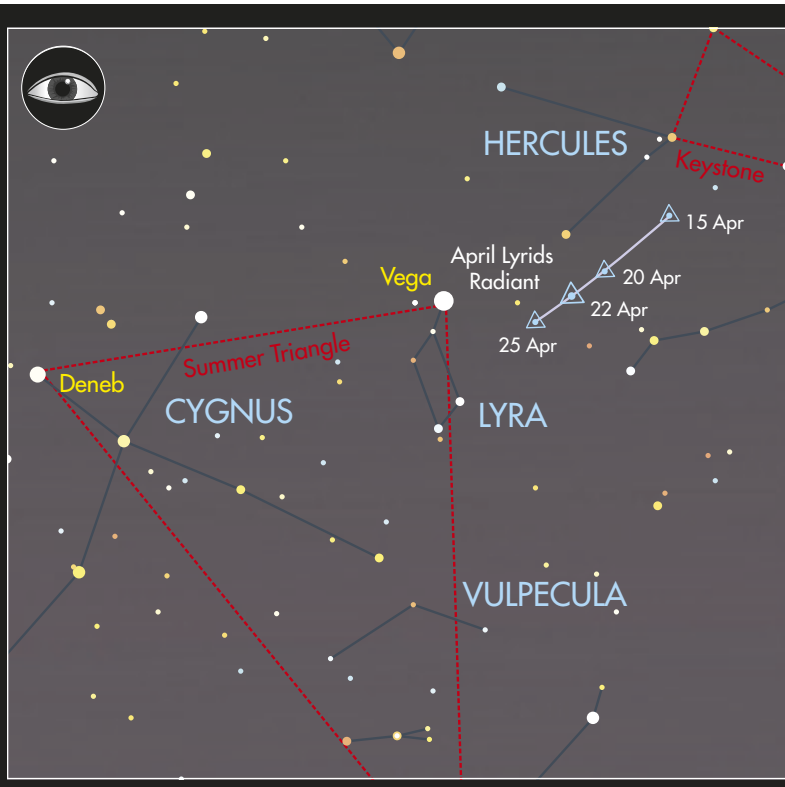
COMET C/1861 G1 Thatcher makes its presence known this month with the return of the April Lyrid meteor shower. This shower is active from 16-25 April every year, with an activity peak on the night of the 22nd/23rd.

The shower results from Earth crossing the debris stream spread around comet Thatcher's orbit. The debris is typically tiny dust particles the size of a grain of sand.

Despite travelling around the Sun in parallel orbits – so effectively parallel paths when the dust particles encounter Earth – the streaks they make when they vaporise in the atmosphere appear to point back to a location close to mag. 0.0 Vega, the alpha star in Lyra. This location is known as the shower's radiant.

April Lyrids are medium-speed meteors, resulting from particles encountering our planet at 48km/s. On the night of 22/23 April, a total zenithal hourly rate (ZHR) of 10 meteors per hour is expected. ZHR is the number of meteors seen under a perfect dark sky with the radiant directly overhead, at the zenith. The figure also assumes an observation of the whole sky at once, which is something that is impossible for the human eye. Consequently, the number of meteors actually seen will typically be lower than the quoted ZHR.

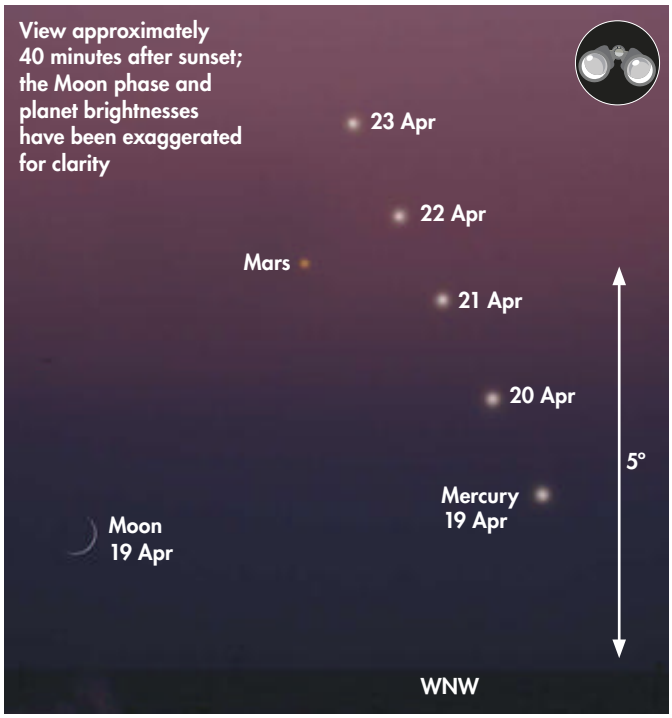
The best time to view the shower is all night on 22/23 April, ideally from midnight on the 23rd through to dawn. The Moon won't interfere much with this year's shower as it'll be a 20%-lit crescent that sets around 23:30 BST (22:30 UT) on the night of the peak. Another plus point for the morning watch is the fact that the radiant is almost overhead as dawn breaks and the higher it is in the sky, the closer to the ZHR the actual observed visual rate becomes.



▲ April Lyrid meteors appear to emanate from the bright star Vega

Mars and Mercury

WHEN: 19-25 April



THE PLANETS MARS and Mercury have a close encounter this month. Both are evening objects towards the end of April, when their meeting takes place, but their proximity to the Sun will make seeing them a little tricky. On the plus side, the angle the ecliptic makes with the western horizon at this time of year is relatively steep and as both planets don't veer far from this line, their time above the horizon after sunset is optimised.

Look low down in the west-northwest after sunset from 21:00 BST (20:00 UT) on 22 April, where you should be able to spot mag. –1.1 Mercury shining away at an altitude of around 5°. Mars lies 1.25° below and left of Mercury and at mag. +1.4 it will be harder to spot. A pair of binoculars is the best way to secure a view of both planets.

If you can get a view of them through a telescope, Mars will be rather disappointing, showing a tiny 3-arcsecond disc, while Mercury will appear as a waning gibbous disc, 78% lit and 5 arcseconds across. All is not lost if it is cloudy on the 22nd, though: the planets will be relatively close during the whole period of 19-25 April.

NEED TO KNOW

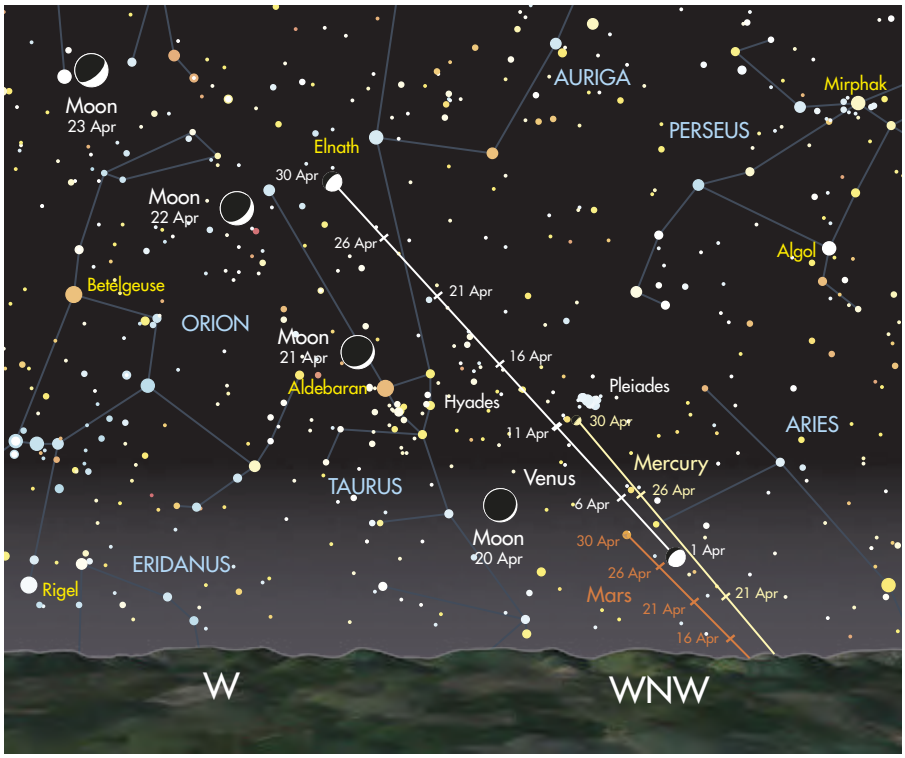
The size of objects in the sky and the distances between them are measured in degrees. The width of your little finger at arm's length spans about 1°.

The planets

PICK OF THE MONTH

VENUS

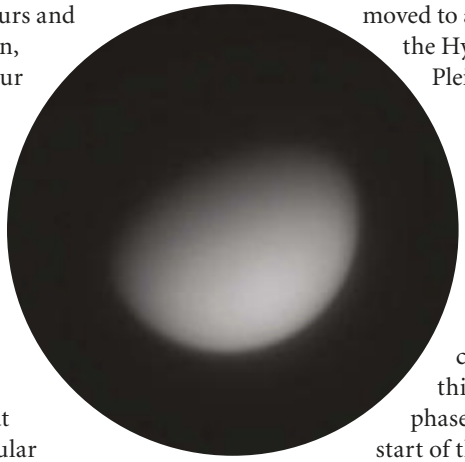
BEST TIME IN APRIL:
30 April, 22:30 BST (21:30 UT)
ALTITUDE: 24°
LOCATION: Taurus
DIRECTION: West
RECOMMENDED EQUIPMENT:
3-inch or larger scope
FEATURES OF INTEREST:
Subtle atmospheric features, phase



Venus remains in the sky long after the Sun has set; seeing it in dark skies adds to its splendour

VENUS IS AN evening object, blazing away towards the west after sunset. Appearing as an intense mag. –4.1 dot, it stands out well even against the bright evening twilight. At the start of April, the planet sets three hours and 40 minutes after the Sun, increasing to around four hours by the end of the month. This means that it will be possible to see Venus against dark skies, making its appearance even more dramatic.

On the 10th, Venus appears 2.75° to the south of the Pleiades open cluster, a sight that will make for a spectacular photo – turn to page 60 to find out how to take one. By the 14th, the planet will have moved to a position between the Hyades and Pleiades clusters.



PETE LAWRENCE X 3

Venus's gibbous phase will shrink during the month

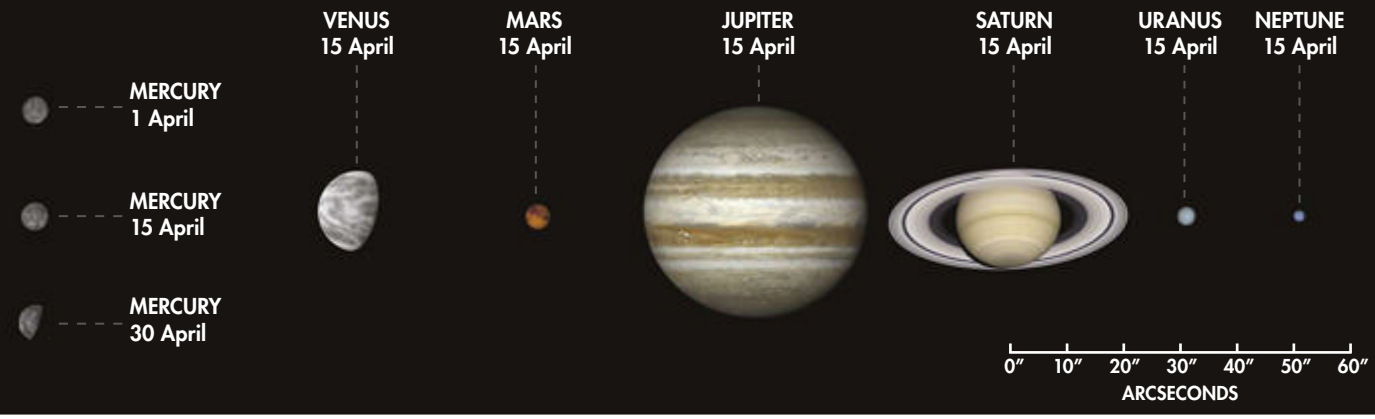
Through a telescope, Venus is both growing and shrinking. Its apparent diameter is increasing as its orbit brings it closer to us. As this happens, its phase shrinks. At the start of the month, the planet has a 78%-lit gibbous phase, decreasing to 67% by 30 April. A telescope will show the phase quite clearly but it pays to be early and catch Venus before it's got too low in the sky. Seen against a bright twilight background reduces the overpowering contrast of the planet and typically delivers a steadier view because of the increased altitude.

There isn't much to see on Venus's disc at first glance, but given time and patience, it is sometimes possible to make out extremely faint shading effects. These get easier to see as Venus comes even closer and its phase begins to reduce significantly.

There's a lovely meeting between Venus and an 11%-lit waxing crescent Moon on the 21st. The Moon will be 11° south of Venus at this time.

THE PLANETS IN APRIL

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



MERCURY

BEST TIME IN APRIL: 22 April 21:00 BST (20:00 UT)
ALTITUDE: 5° (low)
LOCATION: Aries
DIRECTION: West-northwest

Mercury doesn't get off to a good start this month, being poorly located in the morning sky. Superior conjunction – when Mercury lines up with the Sun on the far side of its orbit – occurs on 9 April, after which Mercury will slowly climb back into view in the evening sky. The first opportunity to spot it will be around the 14th, when the mag. –1.7 planet will be low in the west immediately after sunset. On the 19th, mag. –1.3 Mercury, the 1%-lit waxing crescent Moon and mag. +1.4 Mars will form a tight triangle low in the west-northwest after sunset. On the 22nd, Mercury and Mars will appear 1.25° apart By the 30th Mercury, now at mag. –0.3, will be just 1.75° south of the Pleiades.

MARS

BEST TIME IN APRIL: 1 April 21:00 BST (20:00 UT)
ALTITUDE: 4° (low)
LOCATION: Aries
DIRECTION: West-northwest

Mars is making a last stand, low in the west-northwest, but it is gradually losing ground to the bright evening twilight glow as it gets closer to the Sun. It has an interesting conjunction with Mercury and the Moon on the 19th, and a close call with Mercury on the 22nd. The Red Planet remains steady at mag. +1.4 throughout the month and sets just 70 minutes after the Sun by the end of April. Telescopically, the planet is a bit of a loss at present. Its apparent diameter is less than 4 arcseconds all month.

JUPITER

BEST TIME IN APRIL: 1 April 21:30 BST (20:30 UT)
ALTITUDE: 55°
LOCATION: Cancer
DIRECTION: South

Magnificent Jupiter carries the early evening planetary banner this month. Lying due south as darkness falls at the start of April, it loses ground to the evening twilight towards the end of the month when it'll appear to the west of south after sunset and, consequently, lower in the sky. The mag. –2.2 planet sits to the east of the Beehive Cluster in Cancer. It is fabulous to view through any size of telescope: a small one will show the planet's disc and the Galilean moons, currently undergoing 'mutual events' where they may be seen to interact with one another on a line of sight basis – see pages 48 and 49. A 59%-lit gibbous Moon lies 7.5° southeast of Jupiter on the 27th.

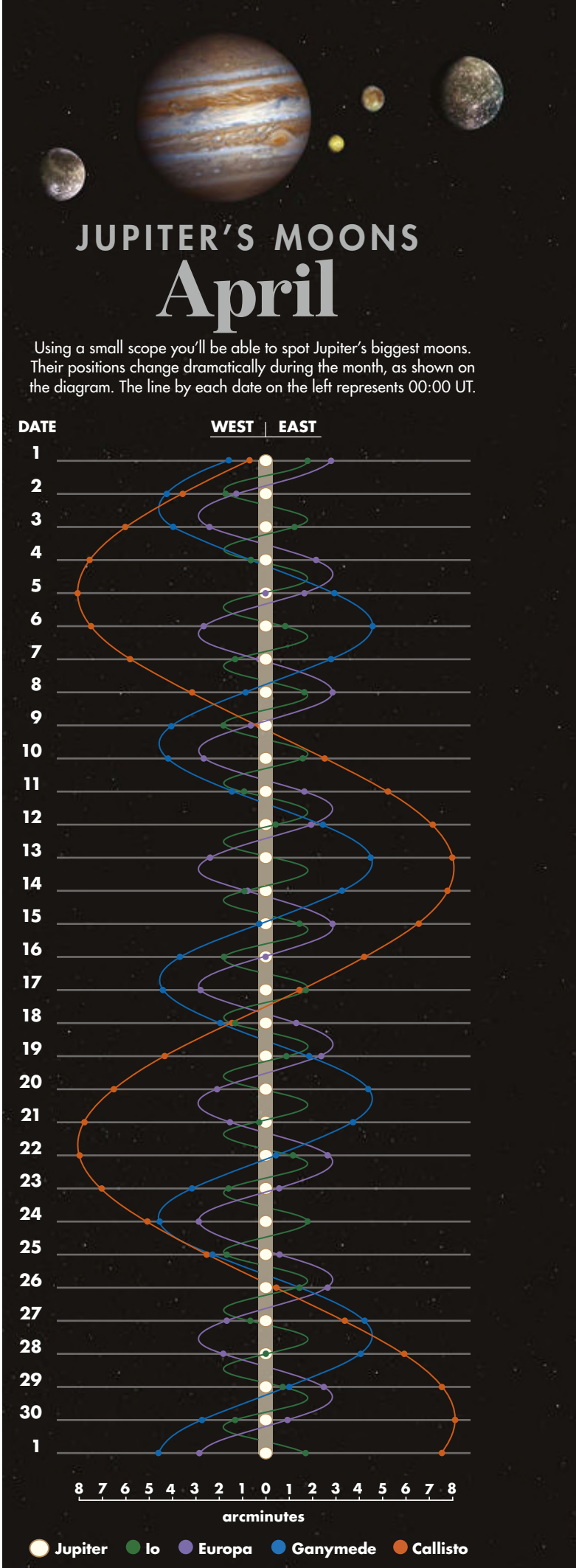
SATURN

BEST TIME IN APRIL: 30 April 02:45 BST (01:45 UT)
ALTITUDE: 18°
LOCATION: Scorpius
DIRECTION: South

Beautiful Saturn is a morning object in the constellation of Scorpius. On the 1st, the mag. +0.3 planet will be 0.5° north of fourth-magnitude binary star Nu (ν) Scorpii. It drifts slightly westward for the rest of April, ending up just over 1° north of mag. +2.5 Beta (β) Scorpii on the 30th. Through a telescope the magnificent ring system that surrounds the planet is now nicely tilted by 25°. Like Jupiter, Saturn also has a good collection of bright moons that can be easily seen with a small telescope.

NOT VISIBLE THIS MONTH
URANUS AND NEPTUNE

See what the planets look like through your telescope with the **field of view calculator** on our website at:
http://www.skyatnightmagazine.com/astronomy-tools



The Northern Hemisphere

KEY TO STAR CHARTS

- *Arcturus* — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Cirdel — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- N / E / S / W — COMPASS AND FIELD OF VIEW
- MILKY WAY

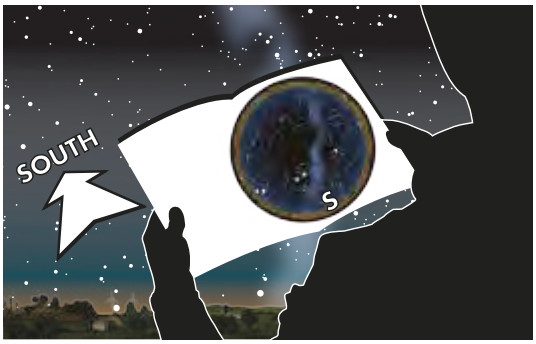
WHEN TO USE THIS CHART

1 APRIL AT 01:00 BST
15 APRIL AT 00:00 BST
30 APRIL AT 23:00 BST

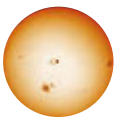
On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.



THE SUN IN APRIL*



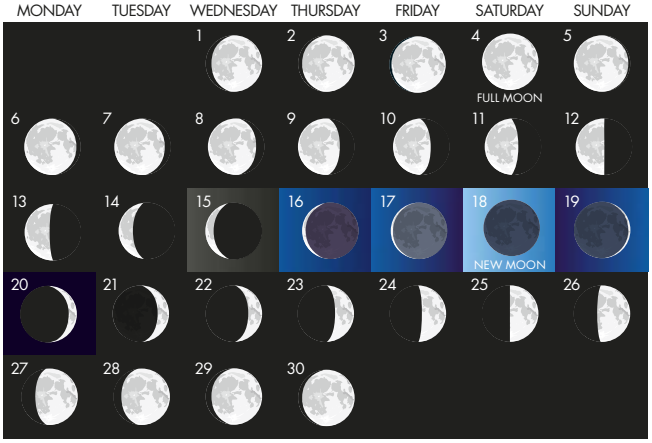
DATE	SUNRISE	SUNSET
1 Apr 2015	06:44 BST	19:44 BST
11 Apr 2015	06:20 BST	20:02 BST
21 Apr 2015	05:57 BST	20:21 BST
1 May 2015	05:36 BST	20:39 BST

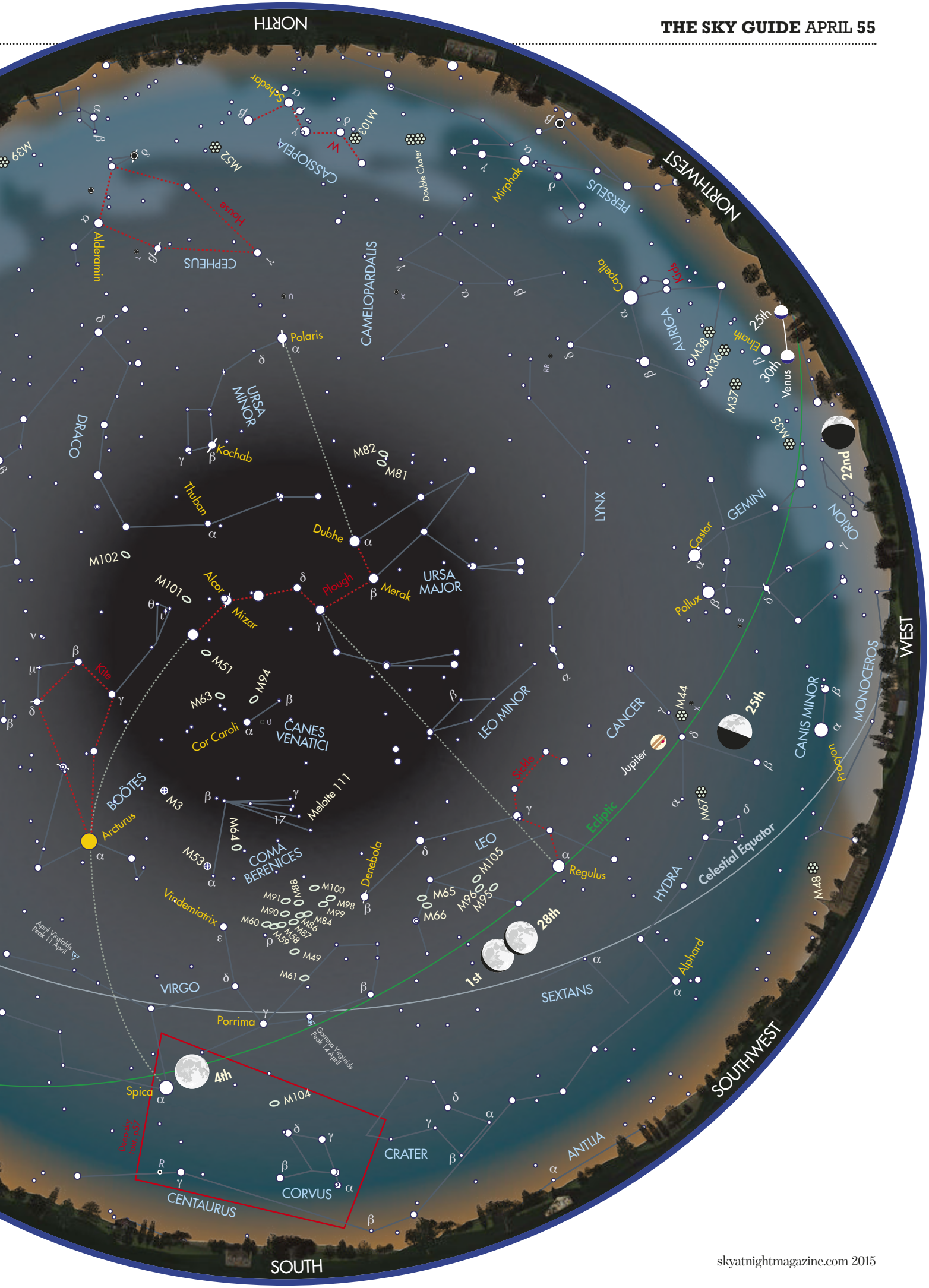
THE MOON IN APRIL*

MOONRISE TIMES

1 Apr 2015, 16:48 BST	17 Apr 2015, 05:35 BST
5 Apr 2015, 21:06 BST	21 Apr 2015, 07:51 BST
9 Apr 2015, 00:18 BST	25 Apr 2015, 11:28 BST
13 Apr 2015, 03:33 BST	29 Apr 2015, 15:41 BST

*Times correct for the centre of the UK




NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
CASSIOPEIA
Schedar
W
M103
Double Cluster
Mirphak
PERSEUS
M52
M39
Alderamin
Phone
CEPHEUS
CAMELOPARDALIS
Capella
Kids
AURIGA
M38
M36
M37
Elnath
25th
30th
Venus
M35
22nd
Polaris
URSA MINOR
DRACO
Kochab
M82
M81
Thuban
Dubhe
LYNX
GEMINI
Castor
Pollux
ORION
M102
M101
Alcor
Mizar
Plough
Merak
URSA MAJOR
Kitle
M51
M63
M94
Cor Caroli
CANES VENATICI
LEO MINOR
CANCER
M44
Jupiter
25th
CANIS MINOR
Procyon
MONOCEROS
BOÖTES
M3
Arcturus
Melotte 111
M64
M53
COMA BERENICES
Sickle
Ecliptic
Denebola
LEO
M105
M65
M66
M96
M95
Regulus
M67
HYDRA
Celestial Equator
M48
M100
M88
M91
M98
M99
M90
M84
M60
M86
M87
M58
M59
M49
Virdemiatrix
April Virginids Peak 11 April
28th
1st
M61
VIRGO
Porrima
Gamma Virginids Peak 14 April
SEXTANS
Alphard
4th
Spica
M104
Delta Centaurids Peak 4 April
CRATER
CORVUS
CENTAURUS
ANTLIA

Deep-sky tour

These six targets in and around the constellation of Corvus are worth crowing over

☑ Tick the box when you've seen each one

The Sombrero Galaxy's hat-like guise is due to the fact it faces us edge-on

1 M68

The small but distinctive constellation of Corvus is our guide this month. Imagine a line from mag. +2.9 Algorab (Delta (δ) Corvi) to mag. +2.7 Kraz (Beta (β) Corvi) and extend it for half the distance again. This will bring you to the field containing mag. +7.8 globular cluster M68 in Hydra. A 6-inch scope shows the globular as a smudge with some of its outer stars resolved. With larger apertures the centre becomes noticeably granular. A 10-inch scope with a high magnification is able to resolve the core quite nicely. This object is 33,000 lightyears away and has a diameter of 106 lightyears. Through a telescope its apparent diameter is 10 arcminutes. ☐ **SEEN IT**

2 NGC 4361

We head into centre of Corvus for our next object, the planetary nebula NGC 4361. Imagine a line from Algorab to mag. +4.0 Alchiba (Alpha (α) Corvi). NGC 4361 lies one-quarter the way along this line. This mag. +10.3, 1.9-arcminute diameter nebula is fairly easy to locate even with small scopes. It has a mag. +13.0 central star, which is again easy to see using high powers. Larger scopes will start to show that the inner portions of the nebula appear layered, with a bright region around the central star and an almost rectangular region around this. The whole appearance gives the nebula an almost grainy texture. ☐ **SEEN IT**

3 THE SOMBRERO GALAXY

Algorab is something of hub for celestial navigation, as you can also use it to locate wonderful spiral galaxy M104 in Virgo, also known as the Sombrero Galaxy. To locate M104, imagine a line from mag. +5.2 Zeta (ζ) Corvi through Algorab and keep going for the same distance again. The 6x2-arcminute galaxy shines away at mag. +8.3 and is easy to find. A 6-inch or larger telescope reveals its shape as well as its signature mark; a dark dust lane that runs to the south of the equatorial bulge. M104 is 28 million lightyears away and estimated to have a physical diameter of 50,000 lightyears. ☐ **SEEN IT**

4 NGC 5068

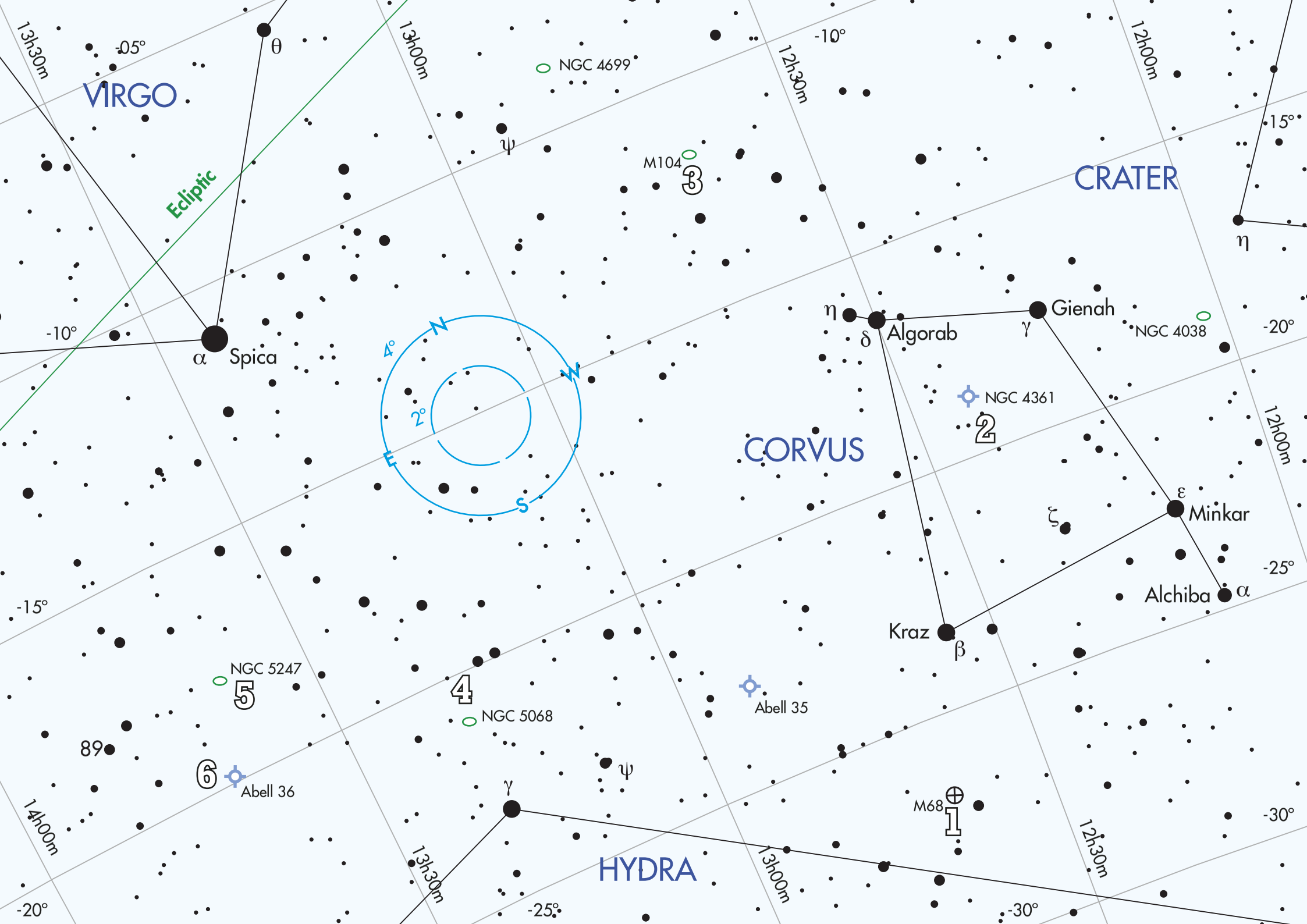
NGC 5068 lies east of Corvus. Imagine a line from Alchiba through Kraz and extend it a little more than 1.5 times to arrive in the right area; alternatively, look 2° north of mag. +3.0 Gamma (γ) Hydrae. This is a mag. +10.0 barred spiral galaxy which, in contrast to M104, appears face-on, and results in the galaxy's surface brightness being quite low. NGC 5068 has a diameter of around 7 arcminutes and requires a large aperture to see properly. A 6-inch scope will just about show it as an indistinct patch, but a 12-inch scope is required to detect the elongated nature of the barred core. Spotting detail in the spiral arms is very tricky. ☐ **SEEN IT**

5 NGC 5247

Mag. +10.5 galaxy NGC 5247 lies 7° northeast of Gamma Hydrae. It appears as a large, diffuse glow around 2 arcminutes in diameter through a 6-inch telescope. With a small scope, the diffuse nature of the glow looks fairly uniform and no central condensation is visible. A 10-inch scope shows the core as a small circular region within the larger outer halo. This is another face-on spiral, though unlike NGC 5068 this one is unbarred. Images reveal that one of the galaxy's spiral arms appears to have split in two. A ninth-magnitude star sits 7 arcminutes to the northeast of the galaxy. ☐ **SEEN IT**

6 ABELL 36

Our final target this month is a challenging planetary nebula, Abell 36. It lies south of NGC 5247, sitting two-thirds of the way along a line from Gamma Hydrae towards fifth-magnitude star 89 Virginis. A 12-inch scope shows the nebula as a faint circular and featureless patch at 100x magnification. It is 13th-magnitude and measures 8x4.5 arcminutes, which is a decent size. Consequently, as was the case with our previous two targets, the surface brightness of Abell 36 is low and this is what makes it tricky to see. Averted vision is the key here, but even so it's not an easy find. Once you suspect you've got it, slowly increase the magnification. Unlike the nebula, the central star is relatively bright at mag. +11.5. ☐ **SEEN IT**


VIRGO
CRATER
CORVUS
HYDRA
Ecliptic
Spica
Algorab
Gienah
Minkar
Alchiba
Kraz
NGC 4699
M104
NGC 4038
NGC 4361
NGC 5247
NGC 5068
Abell 35
Abell 36
M68
N
E
S
W
4°
2°
13h30m
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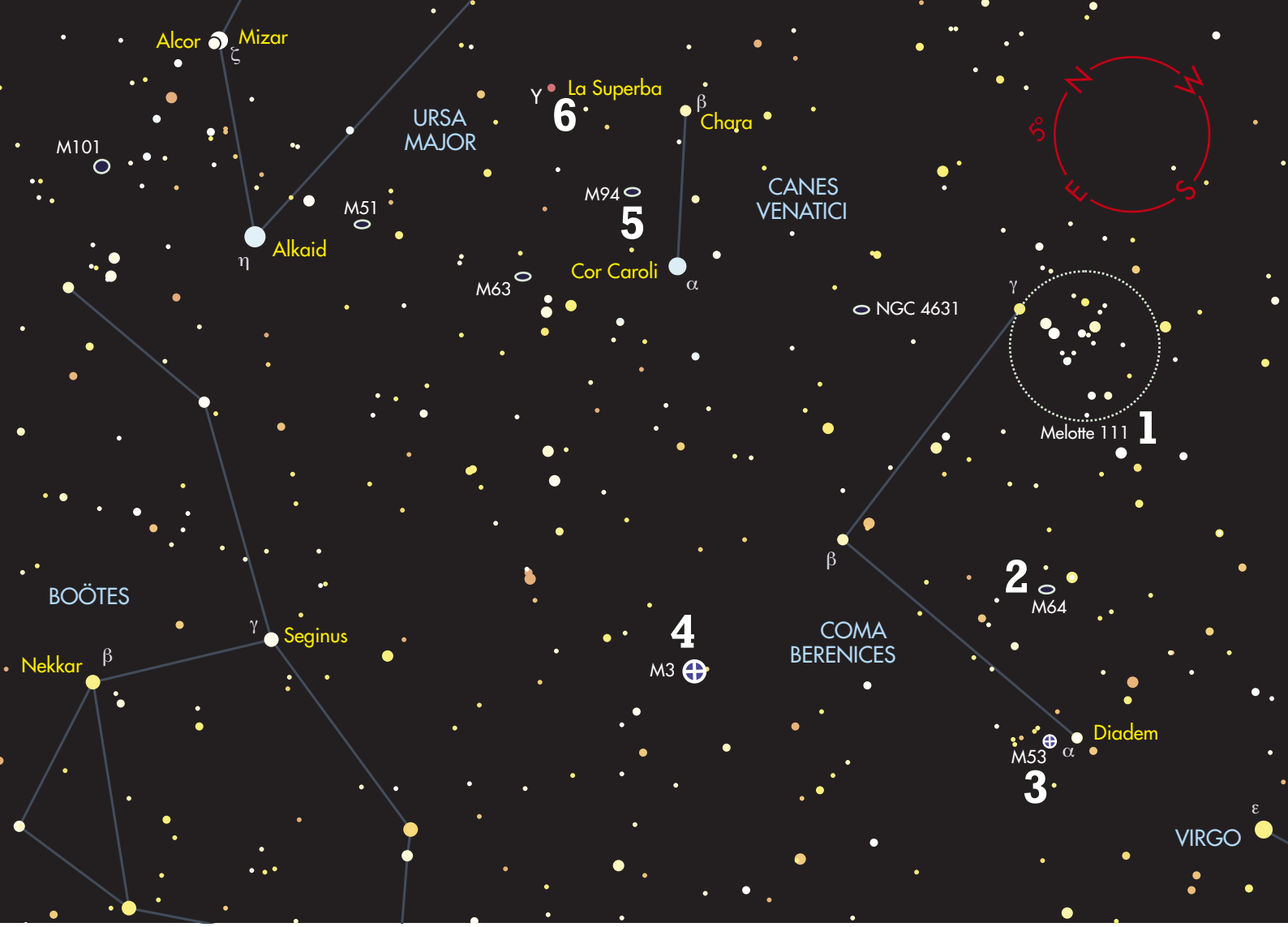
-10°
-15°
-20°
-25°
-30°



With **Stephen Tonkin**

Binocular tour

Shorn tresses, spiral galaxies and a spectral wonder await in the April skies

☑ Tick the box when you've seen each one

1 MELOTTE 111

10x 50 This large open cluster, colloquially called Berenice's Hair, is a superb object for binoculars. Turn your eyes towards mag. +4.4 Gamma (γ) Comae Berenices and you should be able to see the misty patch of sky representing Melotte 111; 10×50 binoculars will reveal 30 or so stars filling the field of view. Melotte 111 has been known since antiquity. In Greek mythology it was the shorn tresses of Berenice, Queen of Egypt, dedicated to Aphrodite in return for her husband's safe return from battle; the Romans knew it as Thisbe's veil. ☐ **SEEN IT**

2 THE BLACK EYE GALAXY

15x 70 Two-thirds of the way between Gamma Comae Berenices and mag. +4.3 Diadem (Alpha (α) Comae Berenices) is the first of this month's galaxies, mag. +8.5 M64, also known as the Black Eye Galaxy. It is quite easy to see in the right conditions – you need a transparent and moonless sky – but do not expect binoculars to show the dark dust lane that gives it its common name. This ancient light left the galaxy 24 million years ago; this is the beginning of the Miocene epoch, about the time that apes and monkeys began to split from our common ancestor. ☐ **SEEN IT**

3 M53

15x 70 Look 1° to the northeast of Diadem and you will find another small misty patch, which will appear to grow brighter and fuzzier if you centre it in the field of view, then avert your gaze back to Diadem or beyond. This is mag. +7.6 globular cluster M53. Its apparent change in size and brightness, which is typical for globular clusters, is a good demonstration of the difference between direct and averted vision. Practice this technique – you will find it to be very useful later in the tour. ☐ **SEEN IT**

4 M3

10x 50 From Diadem, imagine a line to mag. +3.0 Seginus (Gamma (γ) Boötis). Halfway along this line, in a relatively sparse region of the sky, you will find mag. +6.2 globular cluster M3. Although it is slightly more difficult to find than M53 it is both larger and brighter, making it very much easier to see. There are over 150,000 stars in this fine cluster, which lies 34,000 lightyears away. ☐ **SEEN IT**

5 M94

10x 50 Find mag. +2.9 Cor Caroli (Alpha (α) Canum Venaticorum) and imagine a line between it and mag. +4.2 Chara (Beta (β) Canum Venaticorum). At the halfway point, look 2° to the east, where you should be able to see a faint glow – though you may need averted vision for this. This is mag. +8.9 spiral galaxy M94. Like all galaxies it is easier to see in dark, transparent skies, so if you are unable to see it in 10×50s either wait for better conditions or use larger binoculars: it is quite an easy spot in 15×70s under typical suburban skies. ☐ **SEEN IT**

6 LA SUPERBA

10x 50 Return to Chara and glance 4.5° in the direction of mag. +2.2 Mizar (Zeta (ζ) Ursae Majoris). Here you should find a deep orange star (it may look pale yellow in small binoculars), the magnitude of which varies from +6.3 to +4.7 over a period of 160 days. This is Y Canum Venaticorum, named La Superba by the 19th-Century Italian astronomer Angelo Secchi not because of its colour, but on account of its beautiful spectrum, in which absorption lines from carbon compounds extinguish much of the light from blue-violet end. ☐ **SEEN IT**

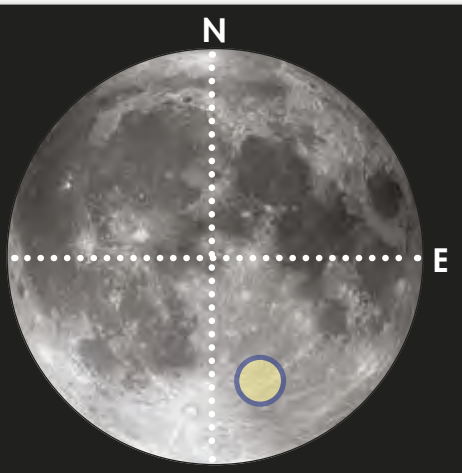
CHARTS AND PICTURES: PETE LAWRENCE

Moonwatch

Gemma Frisius

STATISTICS

TYPE: Crater
SIZE: 88x88km
AGE: 3.9-4.6 billion years
LOCATION: Latitude 34.3°S, longitude 13.4°E
BEST TIME TO OBSERVE: Six days after new Moon or five days after full Moon (9-10 and 25 April)
MINIMUM EQUIPMENT: 2-inch refractor



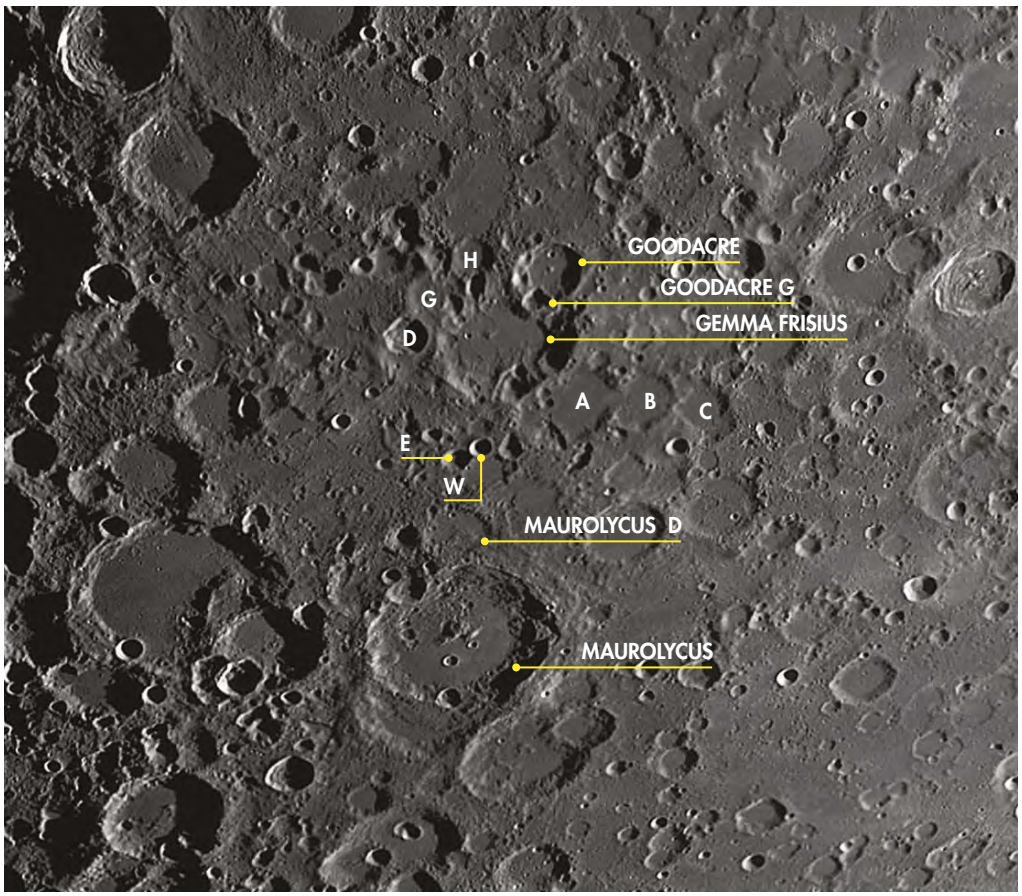
GEMMA FRISIUS IS an 88km-wide crater located in the Moon's 'southern badlands'. This is the informal name given to the heavily cratered highland region, visible – as you might guess – in the south.

The most obvious feature in this region is the rather famous ray crater Tycho (86km) which sits 630km to the southwest of Gemma Frisius. However, so dramatic are the rays spreading out from Tycho that the craters are linked by one of its more prominent ejecta rays.

Gemma Frisius is heavily eroded by smaller impacts and these add extra 'texture' to its appearance when the terminator is close by. In the southeast its rim appears almost totally composed of small craters with diameters of around 10km or less. A true rim appears to the west of this group and defines the southwest edge of the crater. The northern half of the rim then becomes lost again, hidden under various small impacts.

The northern rim is also bounded by four craters of decent size. Arranged from west to east these are Gemma Frisius D (28km), G (37km), H (28km) and Goodacre (46km). Goodacre G (16km) marks the southern edge of Goodacre and acts as a bridge between it and Gemma Frisius. The positions of the three approximately 30km craters and Goodacre around Gemma Frisius has caused this visually striking arrangement to be likened to a giant lunar paw print.

"The floor is mainly flat, but there is a central peak offset to the northwest"



The badlands can be confusing to navigate around – use the 'paw' of Gemma Frisius to keep your bearings

The floor of Gemma Frisius is mainly flat, but does show a small central peak offset to the northwest. A small craterlet, 5km Gemma Frisius M, sits just to the west of this peak. The terrain adjacent to the southeast, where the heavily eroded rim passes onto the main floor, is also quite rough.

A line of three curiously similar, overlapping craters can be seen off to the southeast. These are Gemma Frisius A (67km), B (41km) and C (35km). Each has a battered rim and a flat, featureless floor. At a glance the arrangement looks like a series of cascading circular pools, heading west to east.

Lying 230km to the south is Maurolycus (114km), a dramatic and better defined crater that experiences the same terminator lighting conditions as Gemma Frisius. The contrast in appearance between them couldn't be more striking, and the reason for this is simply that Maurolycus is a more recent addition to the badlands and so less interrupted by the effects of subsequent cratering.

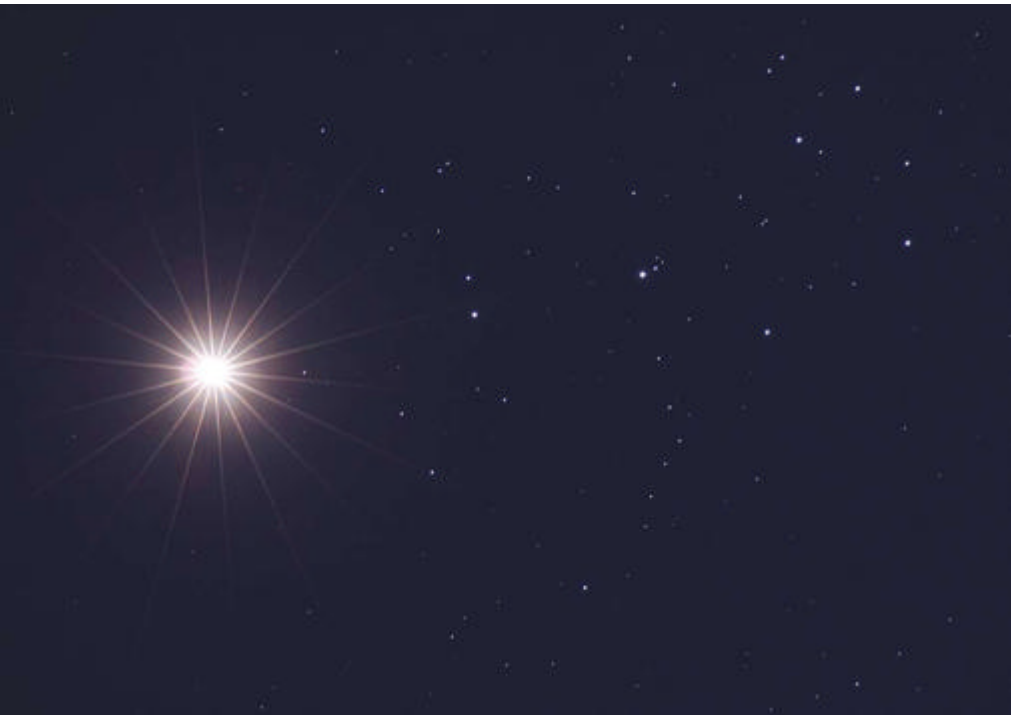
Maurolycus retains most of its original rim, which looks sharply defined and terraced. Its floor, like that of Gemma Frisius, is mainly flat, but the central peak complex is much better defined and this time central. The terrain between the two is typically complex for the southern highlands and crossed by various craters of differing sizes.

Astrophotography

Getting creative with Venus

RECOMMENDED EQUIPMENT

DSLR camera, remote shutter release, driven tracking mount and lens options with focal lengths between 35mm and 200mm



Starburst effects may not be scientifically accurate, but they add a certain something to your photos

Venus is such a dramatic planet to see visually, and photographically – because it's essentially an intense point source of light – there are lots of interesting things you can do with it. In this respect, it's a bit like a light tool to play and be creative with. Making use of things we normally try to reduce in astrophotography, such as diffraction effects, hazy cloud and star trailing, can actually be made to work to our advantage here. Add in the fact that Venus often has some great close encounters with other bodies and this is definitely a planet for the creative mind.

It's the planet's brilliance which makes it such an exciting and interesting subject for photography. One of the more dramatic effects that can be employed, when photographing Venus against a dark sky with a normal photographic lens, is to stop the lens down slightly. The blades of the lens aperture stop create diffraction effects, which cause the bright dot of Venus to sit at the centre of a spectacular ray pattern.

The spring evening twilight skies can sometimes be beautifully crisp and clear, but more often than not it is plagued by clouds or thin haze. As long as the clouds are not fully blanketing the sky, you can make use of them for some interesting photographic effects: if the clouds are crisp, a shot of Venus peeking out from behind them can be a real stunner; if they are misty, you can capture Venus's light shining through the haze layer. This is especially obvious in exposures of several seconds or tens of seconds.

As Venus moves relatively fast against the background stars, another source of photographic excitement comes from the various objects it encounters along the way. This month, Venus passes close to both the Pleiades on 7-15 April and the crescent Moon on 20-22 April.

Venus is so bright that it can be recorded by a point-and-shoot camera or a smartphone. However, to get the best results – and capture some of effects mentioned earlier – you'll need a camera that offers a high degree of control over its settings, such as a DSLR. Likewise, a fixed platform such as a tripod is great for basic shots of the Moon and Venus, especially when the twilight is still bright and limiting longer exposures, but a tracking mount will give more flexibility and help you to keep the bright dot of Venus sharp and circular when you're trying to get creative.

The meeting of the crescent Moon and Venus provides an interesting opportunity to capture the earthshine; the dim light that illuminates the night-time portion of the Moon's disc. Deliberately overexposing the Moon to pick out earthshine with the aperture stopped down as described earlier will create a dramatic starburst effect on both the Moon's crescent and Venus. A tracking mount will also come in handy when trying to record the meeting between Venus and the Pleiades. Extending the exposure should allow you to capture the planet, cluster stars and the misty blue nebulosity that pervades through the region.

KEY TECHNIQUE

TREAT VENUS LIKE A STAR

Venus is frequently referred to as the Evening or Morning Star, depending on which side of the Sun it happens to be on. When it's to the west of the Sun, the planet can be seen in the morning sky before sunrise. When to the east, as it is now, it appears in the evening sky after sunset. Of course, this title is very misleading because Venus isn't a star at all. However, to the naked eye it is a bright point source of light, indistinguishable from the other night time stars that appear around it as the sky darkens.

✉ Send your image to: hotshots@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

STEP-BY-STEP GUIDE

STEP 1 Lens choice is important. For the Venus-Pleiades encounter a 35-70mm focal length is ideal, with 100-200mm being good for closest approach. The Moon-Venus encounter also has the Pleiades on offer. A focal length in the range of 35-50mm will give you a lot of options, though use a 100mm for closest approach on the 21st.

STEP 2 Tripods are great for short exposures with short focal length lenses because star trailing is hardly visible. However, long exposures can work too. Set ISO to 100 and stop down to between f/8-16. A few minutes exposure taken with the camera in bulb-exposure mode, using a remote shutter release, deliberately shows dramatic trails.

STEP 3
A tracked long exposure can be achieved by piggybacking the camera on an equatorially mounted scope or a dedicated equatorial platform. Stopping the lens down to f/8-16 with an ISO around 200-400 can produce some amazing starburst effects. Experiment with exposure, starting off with 30 seconds. If it's too dark, increase the exposure length. If too light, decrease it.

STEP 4 In milky skies, Venus's light passing through the haze layer can sometimes produce interesting effects. Again, experimentation is the key. Start with a mid-range ISO setting of between 400-800, and a fairly low aperture stop value, say f/3.5 or f/4. Begin with a 30-second exposure and adjust according to the results.

STEP 5
When the Moon's close to Venus it'll be a crescent, so it should be possible to see the dark portion of the Moon's disc glowing gently due to earthshine. A mid to high ISO and one- or two-second exposure will overexpose the crescent but bring the earthshine-lit portion to life. Close the lens aperture down to add in an interesting starburst effect caused by diffraction on the lens aperture blades.

STEP 6 It's a common error to home in on objects that are close but forget the surroundings. If there are other targets on offer, remember to take a wide-field shot – for tips on how to do this, see page 32. Venus's proximity to the Pleiades means that the Hyades will be nearby too, and the contrast makes for a great starry backdrop.

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The Carina Nebula looks nothing like this to the VLT; its data simply reveals a map of radiation, which needs to be processed into this more familiar guise

THE ART OF SPACE IMAGING

How is infrared data from ESO's Very Large Telescope turned into stunning images? **Rob Banino** finds out in the second part of our irregular series

ABOUT THE WRITER

Rob Banino has spent the last 12 years working as a journalist. He has also worked for *BBC Sky at Night Magazine*'s sister science title, *BBC Focus*.

ESO/T. PREBISCH

▲ The final shots can be quite complex; this one of the Orion Nebula is actually a composite of 81 images

◄ VLT images are often the public face of research. This one of the area around our Galaxy's black hole is the result of a 16-year study

Perched 2,635m up on the Cerro Paranal mountain plateau in Chile's Atacama Desert is the world's most advanced optical instrument – the Very Large Telescope (VLT). Comprised of an array of four main telescopes, each with an 8.2m mirror, and another four auxiliary scopes with 1.8m mirrors, the VLT enables astronomers to observe objects that are too far away and too faint for most other ground-based telescopes to see.

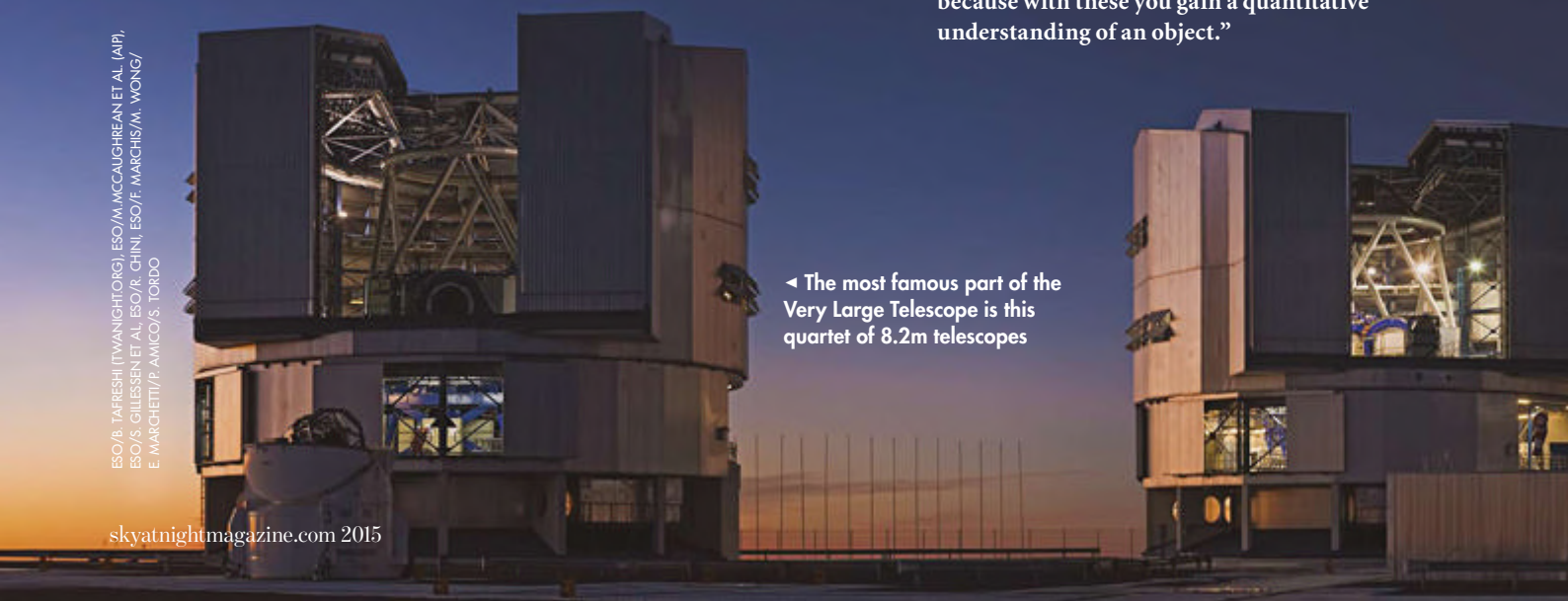
Thanks to the spectrographs allied to its scopes, the VLT can also perceive light beyond our visible spectrum – light that exists in the infrared and ultraviolet bands. But if the VLT can see things we can't, how do you show its observations? The answer, in short, is to turn those observations into something we *can* see.

What the eye doesn't see...

"I would call it a translation," says Lars Lindberg Christensen, the European Southern Observatory's head of public outreach. "You have to translate the raw data into wavelengths suitable for our eyes – so red, green and blue colours – and also translate it from the very high dynamic range that an image has when it is observed by a telescope into the dynamic range we can see."

The trick to understanding this process is not to think of the VLT as a device that 'sees' the far reaches of space, but as one that measures levels of electromagnetic radiation. The measurements, stored digitally as Flexible Image Transfer System (FITS) files, can then be translated into image form, to enable the public to see what the astronomers are using the VLT to study.

"Astronomers don't need 'true' colour images of the Universe," says Christensen. "They want to probe particular parts of the spectrum where there is some astronomical information. They might use the images to gain some understanding of an object but it's less important for them whether a given colour is represented as, say, an orange or a red. Most of the science is done with numbers and spectroscopy, because with these you gain a quantitative understanding of an object."



◄ The most famous part of the Very Large Telescope is this quartet of 8.2m telescopes

ESO/B. TAFRESHI (TWANIGHT.ORG), ESO/M.MCCAUGHREAN ET AL. (AIP), ESO/S. GILLESSEN ET AL. ESO/R. CHINI, ESO/F. MARCHIS/M. WONG/ E. MARGHETTI/P. AMICO/S. TORDO

So how do you translate those measurements into a picture? After all, as Christensen points out, if you took the information gathered with an infrared imaging device and turned it into a 'true' colour picture, it would be black. "There would be visual information there, but we wouldn't be able to see it because it's infrared."

But as he explains, you could represent that information in a different way. Typically what happens is that 'true' colours are assigned to non-visible wavelengths of light to produce an approximation of their appearance. For example, if the measurements record an object emitting non-visible light that has spread across the infrared range, the reddest light is assigned a red and the least-red light is assigned a blue. Anything in-between becomes a green. Three separate pictures are produced using the individual colours, and these are then combined and balanced to form the finished article.

"That process can be tricky to get right," says Christensen. "We have ethical guidelines to make sure that the final image is a representation of nature and doesn't cross over into science fiction or Hollywood. For instance, we can never put something into an image that's not there. We can, however, remove instrumental effects, which is something we spend quite some time on. Often the CCDs produce some funny effects and we typically try to remove those, so that we represent the object more accurately."

Not just pretty pictures

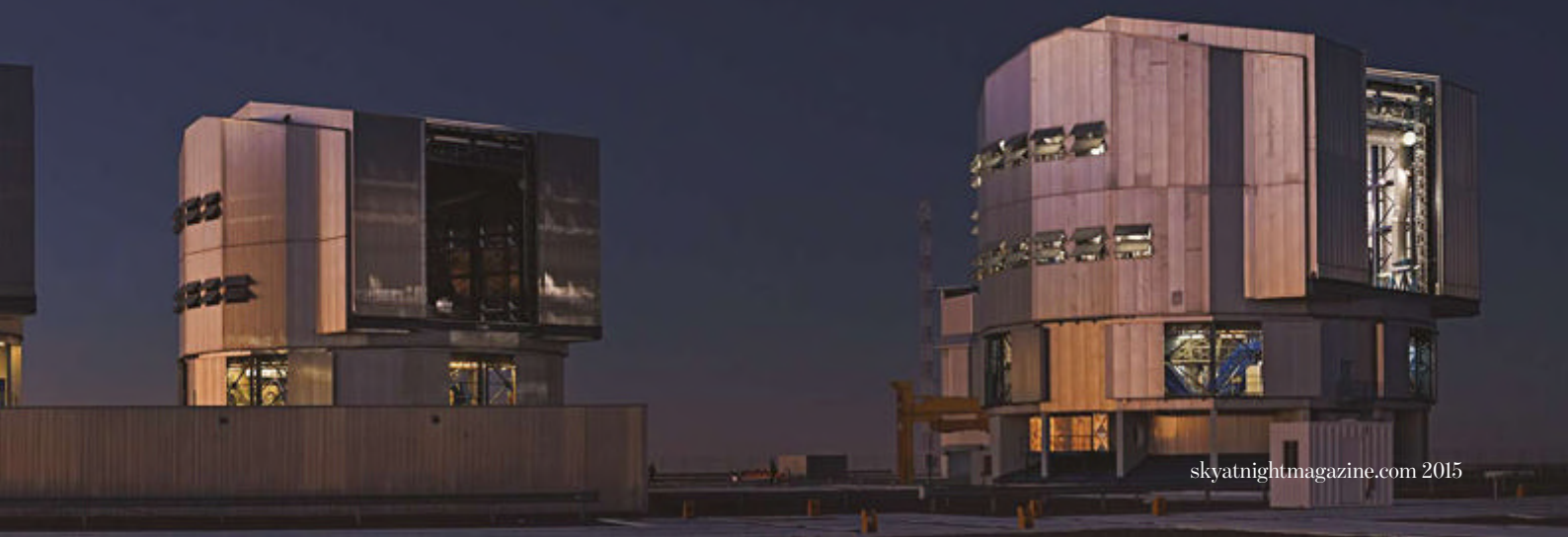
Accuracy has to be balanced with aesthetics, though, because while the images may not be the primary concern for the astronomers, Christensen knows they still have a job to do.

"The purpose of these images is to give people something back in return for their investment in the telescopes and the science they enable us to do," he says. "We believe that by sharing these images, people get an insight into the science and very often the best views of objects that have never been seen before.

"Scientifically speaking, you can argue that the value of the images is perhaps limited," he continues. "But I would say it's very important for our cultural history to produce them."

▲ Non-visible wavelengths help us see the Universe in new ways; in visible light, the stars at the heart of M17 would be obscured by dust

► Even the planets can seem unfamiliar when imaged in non-visible wavelengths



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Main image of Pleiades M45 Cluster taken using Vixen Polarie Star Tracker © John Slinn

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RELIGIOUS OBSERVANCE

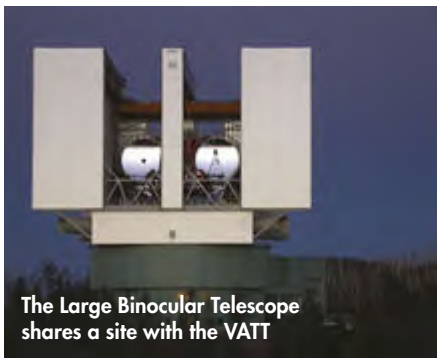
THE VATICAN OBSERVATORY

A lot has changed at the Vatican in the 400 years since Galileo was declared a heretic – for astronomy and for the Church. **Eagle Gamma** investigates

In the mountains of southern Arizona lurks the VATT, a telescope owned and operated by the Vatican

Arizona's Pinaleño Mountains are home to two large telescopes

An external view of the VATT observatory



The Large Binocular Telescope shares a site with the VATT

The Pinaleño Mountains, in the deserts of southeast Arizona, are a far cry from the Vatican in Rome. It's the Wild West, the frontier. And it is here that the Vatican has built its newest astronomical instrument.

The Catholic Church has had a long and complex relationship with astronomy. Some four centuries after Galileo came into conflict with the Church for his heliocentric view of the Universe, the Vatican's own astronomer-priests now study galaxies and cosmology.

In Tucson, Arizona – one of the astronomical world's major hubs – the Church has set up a research group. But it is here in the nearby Pinaleño Mountains that it has built the Vatican Advanced Technology Telescope (VATT) to scan the skies. The telescope is currently housed in the Pinale Mount Graham International Observatory, over 3,000m above sea level. But what does the Vatican use its newest, fastest instrument to investigate?

The Vatican research group covers subjects from meteorites to stars and metagalactic structures. Working in concert with the Very Large Array, they have examined rare micropulsars. These brown dwarfs emit powerful radiation in bursts that reach Earth, and the array measures how they change over time. The Church also conducts research into more unusual topics, including stars that have been stripped from one galaxy and amalgamated into another, and heterogenous cosmology, which takes away the assumption that on large scales the Universe is the same in every direction.

Our place in the Universe

"We have a special home," says Father Paul Gabor, vice-director of the Vatican Observatory Research Group. "The solar neighbourhood is not quite typical," he says. "It seems that the Sun is in a bubble."

The density of the interstellar medium around us appears to be below average.

THE POPE AND **THE ASTRONOMER**

The interaction between the Vatican and astronomy began before Galileo. The Church became interested in astronomy due to inaccuracies in its calendar, apparent when scheduling Easter. This resulted in the Gregorian calendar in 1582 (named after Pope Gregory XIII), which we still use today.

The centrality of Earth became an essential element of Catholic doctrine, and heliocentric models were considered heretical. When Galileo looked through a telescope and observed a complex system of planets and moons orbiting the Sun, he stumbled into a tumultuous history of conflict.

But the Vatican comes in only to decide on controversy, not to make everyday decisions, says Gabor, who denies the very controversy of the Galileo affair, alluding to the informal way that laws operate in Rome: "When a book was on the List of Prohibited Books, it meant that it was to be read only by those who had the correct preparation. In that sense, the Bible itself was a blacklisted book."

Controversy or not, the Church has changed its attitude to astronomy dramatically. Ever since astronomical revelation first conflicted with cosmological doctrine, humanity has had a different relationship with the Church. Now, even the Vatican, whose supporters at first refused to look through an eyepiece, turns to observational evidence.

Galileo was twice tried by Church authorities



▲ Left to right: The Crab Nebula, the Horsehead Nebula and the Black Eye Galaxy, as imaged by the Vatican Advanced Technology Telescope


The VATT's 1.6m Gregorian scope (top) uses a concave mirror ground locally (bottom)

VATT looks at stars that will evolve to look like the Sun does today, searching for clues that might answer an age-old question: how normal is our neighbourhood? The answer has huge implications.

Christian Veillet, director of the Large Binocular Telescope Observatory, has an office in the same building as the Vatican's in Tucson and a telescope at the same site on Mount Graham. He believes that our findings affect our sense of self. "If we can gather more information on how unique our Solar System is, I think it will have an impact on our own perception of what we are in the world." A key question revolves around the search for other planets which may harbour life. "Can we find life evolved in a way where there is this consciousness?" he asks.

Advanced technology

To help answer these questions the VATT uses some unusual technology. Primarily built to conduct surveys, it scans the skies for small objects while taking in larger-scale structure. Its 1.8m Gregorian telescope differs from a Cassegrain in using a concave rather than convex secondary mirror.

The primary mirror on the 'Pope scope' – as local astronomers like to call it – was created at the University of Arizona Mirror Laboratory, using new casting and polishing techniques. These skills would go on to shape the primary mirrors of the Giant Magellan Telescope and the Large Synoptic Survey Telescope, as well as the Large Binocular Telescope, which sits within sight of the VATT.

VATT's primary mirror has an unusually short focus of f/1. This places the image at a distance equivalent to the mirror's diameter, meaning the telescope setup is quite small and can rotate rapidly. Combined with an extremely fast camera that has a readout time of only two milliseconds, the result is a formidable scientific instrument.

Despite winter snow, the site has good seeing all year, providing many nights of observations. With its glistening dome, the observatory looks modern and clean. There is nothing to separate the VATT from any other scientific telescope trying to answer the questions of the Universe.

For many Catholic astronomers, the observation and analysis of the Universe constitutes an attempt to understand the mind of God. In this sense, some consider the Bible one book of God, and nature the other book. Many Catholics now conceive of the entire scientific enterprise as fully consistent with their religion. Veillet, a secular astronomer, can also see why astronomy bears on religion. "Knowing our place in the world is important, at any level. It's true for our relationships, including our faith in God."

ABOUT THE WRITER

Eagle Gamma is a writer specialising in astronomy and astrophysics. In the course of his work he has visited most of the world's leading observatories.

GOD AND THE VATT

Jesuit astronomer Paul Gabor describes himself as "basically an instrumentalist, but also with an interest in exoplanets". He leads the Vatican Observatory Research Group, which he says serves as a bridge. "Our mission is twofold," he says. "To explain the Church to the world of science and to explain science to the Church. We do better at the former."

Gabor converses on a wide range of topics touching on astronomy and religion. He criticises modern philosophy of science, in which "you move from darkness to the light", an idea he calls "complete nonsense". Instead, he sees a cyclical history that he hopes will erase conflict between science and religion.

Merely the presence of phenomena such as electromagnetic radiation, which permit astronomy, strengthens Gabor's Catholic faith. However, he says his faith precedes his research activities. "If astronomy tells us something about God, it is this: God wants to be known. That on its own is a very powerful statement."

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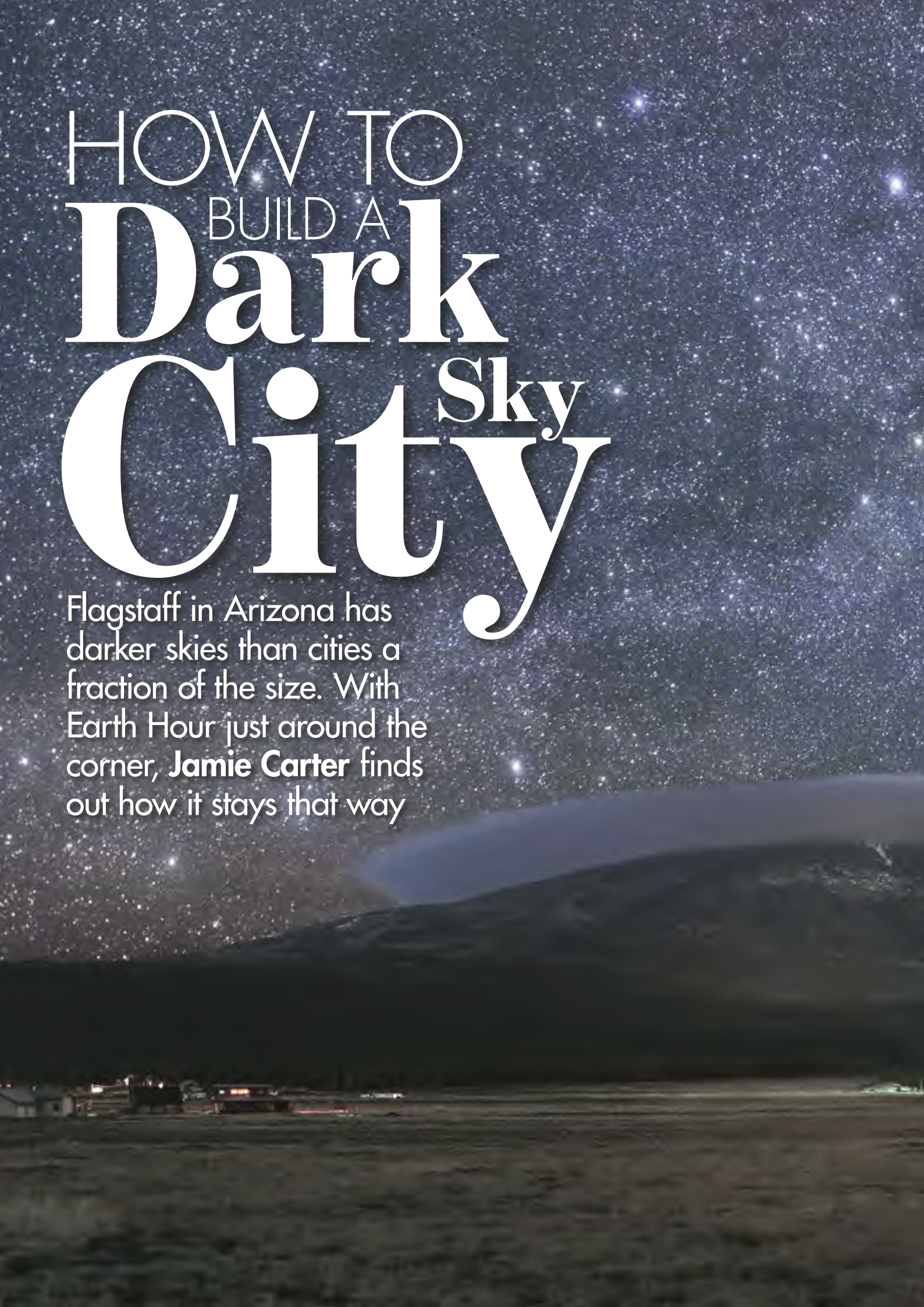

HOW TO BUILD A Dark Sky City

Flagstaff in Arizona has darker skies than cities a fraction of the size. With Earth Hour just around the corner, **Jamie Carter** finds out how it stays that way

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Lowell Observatory is just off America's Route 66, a major migration trail of old

Route 66 is known as America's 'Mother Road', but in Flagstaff, Arizona, it's also a main street to the stars. Barely a mile from the city centre the famous old highway forks to Mars Hill, home of Lowell Observatory, from where Pluto was discovered in 1930.

Flagstaff is high, dry and dark. So dark, in fact, that it's the world's first Dark Sky City. Perched in a vast Ponderosa pine forest at 7,000ft (2,130m), there's little moisture up here; the seeing is good, and there are around 250 clear nights each year. Perfectly placed for stargazing it may be, but how on Earth do you keep a modern, growing town of 70,000 people dark?

You make light pollution illegal, that's how. "It was pretty simple 60 years ago, but we were the first town to adopt laws to try to protect the night sky," says Chris Luginbuhl at Flagstaff Dark Skies Coalition, a retired astronomer from the nearby US Naval Observatory. Since then Flagstaff has become a model for how to keep urban skies dark. Brightly lit billboards along highways have come down, garage forecourts have received canopies to restrict sky glow and in the past 25 years sparsely placed low-pressure sodium bulbs have spread their gentle orange light around the city. He admits that the historic lighting restrictions have a lot to do with the close position of Lowell Observatory, which has been on Mars Hill since 1894. "Flagstaff has grown up with the observatory – it was here when the ▸

MAIN PICTURE: D. M. DURISCOE/COURTESY OF FLAGSTAFF DARK SKIES COALITION, JAMIE CARTER

▸ town was nothing more than a train stop in the middle of the forest – but the formation of the Dark Skies Coalition was an attempt to remove the full onus from observatories and try to get it out into the community."

It was Luginbuhl and his colleagues at the Flagstaff Dark Skies Coalition who proposed the idea of the town becoming a Dark Sky City – a concept that didn't exist at that time – back in 2001. Proposed to, and accepted by, the Tucson-based International Dark Sky Association, the designation has since spread to seven other urban areas. Now called Dark Sky Communities, the roll-call includes Beverly Shores in Indiana, Dripping Springs in Texas and most recently Sedona, just 48km south of Flagstaff.

The quest continues

But you can't equate Dark Sky Cities and Communities with International Dark Sky Parks and Reserves, where light pollution is virtually banned. Dark Sky Communities are designed only to reduce light pollution, or slow its growth; Flagstaff remains a bright spot on the map compared to nearby national parks and wilderness areas. "The Dark Sky Communities are darker than your average community, but that's all they are – they still might have pretty bright skies depending on population density," says Luginbuhl. "Flagstaff is about 25 per cent darker that your average town."

▲ The coalition continues its efforts to promote the value of dark skies to Flagstaff's residents

Despite the designation, there is still work to do in spreading the message beyond the astronomical community. "The people who make decisions around here tend to pigeonhole us – they're happy to support dark skies and have good lighting codes because they want to support the observatory," says Luginbuhl, though few members of the Flagstaff Dark Skies Coalition are astronomers.

"The Flagstaff lighting ordinance is pretty dramatic," says Jeff Hall, director at Lowell Observatory, who shows me an all-sky image taken halfway between Winslow, population 10,000, and the 70,000-strong Flagstaff. Winslow looks much brighter.

Hall says that Flagstaff is doing very well indeed, yet serious astronomy is beginning to leave the town. Though work continues up on Mars Hill, Lowell Observatory's latest eye on the sky – the magnificent Discovery Channel Telescope – is 65km to the south at Happy Jack on a remote outcrop surrounded only by forest. "Even with the world's best dark-sky ordinance you would never build a 4.3m telescope right next to a city of 70,000 people," says Hall. "It just wouldn't make sense."

Yet Flagstaff's cleverly devised lighting zones, which restrict the level of lumens (a measure of the amount of light visible to the human eye from sources such as ▸

DARK SKIES COALITION, © CHARLES CLAUDE/ALAMY, JAMIE CARTER X 3, FLAGSTAFF CONVENTION & VISITORS BUREAU, US NATIONAL PARK SERVICE, ISTOCK

The Milky Way shines brightly near Flagstaff, but it's not so easy to see directly over the city

A DREAM DESTINATION **FOR STARGAZERS**

The region surrounding the Dark Sky City has plenty to tempt the astronomically minded

METEOR CRATER ▼

Since the meteor airburst over Chelyabinsk in 2013 there's been a lot of talk about near-Earth objects and the devastation they could wreak, but just as famous is the jaw-dropping site 48km east of Flagstaff where an airliner-sized chunk of space rock struck Earth 50,000 years ago. Just over 1km in diameter, it's an impressive sight from the viewing platform at the rim, which has an excellent museum attached as well as trails and telescopes.

Meteor Crater, Interstate 40, Exit 233, Winslow, Arizona. Open summer 7am-7pm and winter 8am-5pm; adults $18, children $9
www.meteorcrater.com

▲ LOWELL OBSERVATORY

Fancy using a 16-inch telescope over 7,000ft up to get eyes-on with the Owl Nebula, the Cigar Galaxy and the gas clouds of the Orion Nebula? Public stargazing sessions are held just a short walk or drive from Route 66 in central Flagstaff, in front of Lowell Observatory's historic Rotunda each night at dusk, with an experienced and friendly team of volunteers manning 12-inch and 16-inch telescopes. The McAllister Dome, home to a second 16-inch telescope, is also open. Other highlights include the Pluto Discovery tour (thanks to New Horizons, 2015 is #yearofpluto) and scale models in the forest of both the Solar System and the Universe.

Lowell Observatory, 1400 West Mars Hill Road, Flagstaff, Arizona
Open 10am-10pm (10am-5pm Sundays); adults $12, children $6
www.lowell.edu

▼ THE OBSERVATORY SUITE, THE INN AT 410

Just three blocks from the centre of town but beyond the intrusion of streetlights is The Inn at 410 historic house, whose fabulous Observatory Suite is strewn with original photography of the Moon, Saturn's rings, the Orion Nebula, Comet Hale-Bopp and more, all taken by local photographer Tom Taylor. Forget a Gideons *Bible*; in its place are *Skywatching* and *The Friendly Guide To The Universe*.

The Inn at 410 B&B, 410 Leroux Street, Flagstaff, Arizona. From $170 per night
www.inn410.com

▲ GRAND CANYON NATIONAL PARK

Few visit this geological wonder for its night skies. Crucial is its high elevation; Grand Canyon Village on the South Rim is at around 7,000ft (2,000m). "We've got a high elevation, dry desert air and really clear night skies," says Ty Karlovitz, a ranger who works in the interpretation division at Grand Canyon National Park. Ty tells me that the second half of September until mid-November is reliably clear. So too is early summer, when a star party is held (it's on 13-20 June in 2015); amateur astronomers come from Flagstaff and Tuscon to set up telescopes behind the visitor's centre for anyone to use, and there's also a talk, constellation tours and guided stargazing. The rangers also have a Celestron SkyProdigy 130 telescope on hand for impromptu stargazing sessions.

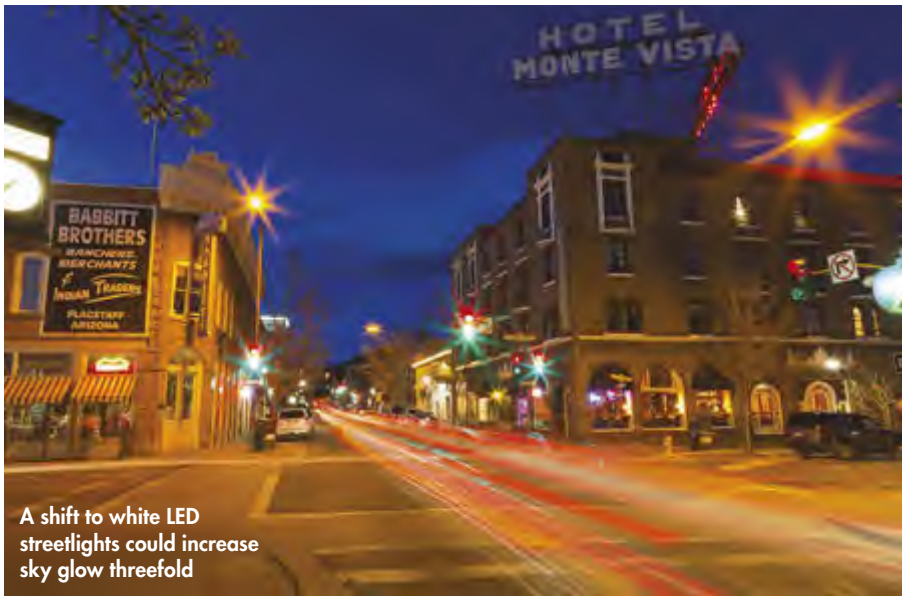
Grand Canyon National Park (South Rim), open all year, $25 per vehicle
www.nps.gov/grca

The Discovery Channel Telescope sits high up on a rocky outcrop surrounded by forest

JAMIE CARTER, © DANITA DELIMONT/ALAMY

▸ streetlamps) that can be emitted per acre, continue to play a critical role in bringing serious astronomical research to Anderson Mesa, a hill just 15km from Flagstaff. Up there, near to Lowell Observatory's four telescopes, sits the US Naval Observatory's Navy Precision Optical Interferometer, an optical analogue of the Very Large Array radio observatory near Socorro, New Mexico. It is 430m across and simulates a mirror of that size through the use of small scopes along its arms.

"They are preparing to upgrade that with four more 1.8m telescopes, at which point it will be the most sensitive instrument of its type in the world, bar none – and it's just a few kilometres from the city," says Hall. "That says a lot about Flagstaff's lighting ordinance that they're still willing to do that."



A shift to white LED streetlights could increase sky glow threefold

The creeping danger

For now, low-pressure sodium bulbs keep Flagstaff reasonably dark for both its population and for astronomers, but both groups are threatened by the creeping popularity of white LED streetlighting, which is perceived to be cheaper and maintenance free by town councils and city authorities. Sadly, the result is a massive increase in sky glow. "When you switch from low- or high-pressure sodium to white light, the sky will brighten by three times," says Luginbuhl, who laments that filtered versions (FLEDs) are still a few years away from being either bright enough or economically viable. "They're not the ones with the research and marketing power behind them – it's all white LED," Luginbuhl adds. Both he and Hall are busy looking for solutions, giving joint presentations on how the various LED technologies threaten dark skies, and they even hosted a Dark Skies Summit last year. Flagstaff's global reputation as a pioneer of lighting ordinance helps, as do surveys like one from Northern Arizona University in 2005 that estimated the Discovery Channel Telescope will bring over half a billion dollars into the northern Arizonan economy. If money doesn't keep skies dark, perhaps environmental concerns will. The now-being-researched effects on insects and nocturnal wildlife could give white LEDs a much shorter shelf life than many expect.

A lot of people think that fighting light pollution in populated areas is a losing battle, and accept that if you want dark skies, you need to head for a national park or a desert. "We created the idea of a Dark Sky City, and we did it to help spread awareness in the community," says Luginbuhl, who insists that nobody is going to protect things they're not aware of and that dark skies are for everyone to enjoy. "To say that the night sky is only for astronomers is like saying that the Grand Canyon is only for geologists."

This is a progressive town where constant pressure on policy-makers by passionate people is having dramatic results, but Flagstaff isn't meant to be a stargazing mecca. It's a never-ending task, but the goal is simple: to make the world think twice before abandoning the night.

ABOUT THE WRITER

Jamie Carter is a tech and travel writer with the astronomy bug. He's a veteran of aurora hunts and eclipse chases around the world.

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SKILLS

Brush up on your astronomy prowess with our team of experts

Spiral galaxies are the type most commonly observed. Top inset is an elliptical, the largest form of galaxy in the Universe; bottom inset is an irregular galaxy, the result of an incomplete merger

The Guide

Know your galaxies

With **Elizabeth Pearson**

How spiral, elliptical and other galaxy 'morphologies' are formed

Galaxies are among the largest and most beautiful objects in the night sky. These huge swirling masses are where almost every star in the Universe is born, lives and dies. But it has only been in the past century that astronomers have understood what galaxies are, and come to realise their importance. Before then, they were thought to be spiral-shaped nebulae on the outskirts of our own Galaxy. To many astronomers they were a nuisance, prone to getting in the way of observations and easy to confuse with comets.

But over the years, interest in these objects grew and so did the controversy about their size. Were they small but nearby, or colossally huge and far away? On 26 April 1920 two astronomers, Harlow Shapley and Heber Curtis, argued on this topic at what would come to be known as the Great Debate. Shapley maintained that the Universe consisted of only one galaxy, our own Milky Way, while Curtis said that we lived in just one of many. In the years that followed, Edwin Hubble went on to measure the distance to the Andromeda Galaxy to be 900,000 lightyears (though

this number has since been revised up to 2.5 million lightyears). This placed it far outside the limits of Shapley's galaxy.

This meant that galaxies were huge. In our own Galaxy, there are at least a hundred billion other stars, ranging from tiny red dwarfs to blue supergiants. They are gravitationally bound together, along with vast clouds of gas and dust, all swirling around a supermassive black hole.

Galaxy types

There are three main categories, or 'morphologies', of galaxy: spiral, elliptical and irregular. While the human eye is very good at telling the difference between these types, it is difficult to program computers to recognise them, making large-scale galaxy categorisation a long and laborious process. This has led to citizen science projects such as Galaxy Zoo, in which thousands of volunteers separate out the different galaxy types. This is important because a galaxy's type tells us where it is in its life cycle.

Though there is much contention about how the first galaxies formed, the current leading theory is that in the early Universe, a few hundred thousand years after the Big Bang, dark matter began to clump together. Hydrogen and helium gas fell towards the huge masses, forming clouds that eventually collapsed to form stars.

It's thought that these first galaxies were spirals. As the original clouds of gas were spinning, these galaxies continued to spin as they formed stars, eventually resulting in the structure we see today, majestic arms sweeping from the centre. Many galaxies have a central bar of stars that these arms stretch out from. These arms contain huge amounts of gas and dust, the raw products required to create stars, and so they are highly active regions with new stars constantly being formed.

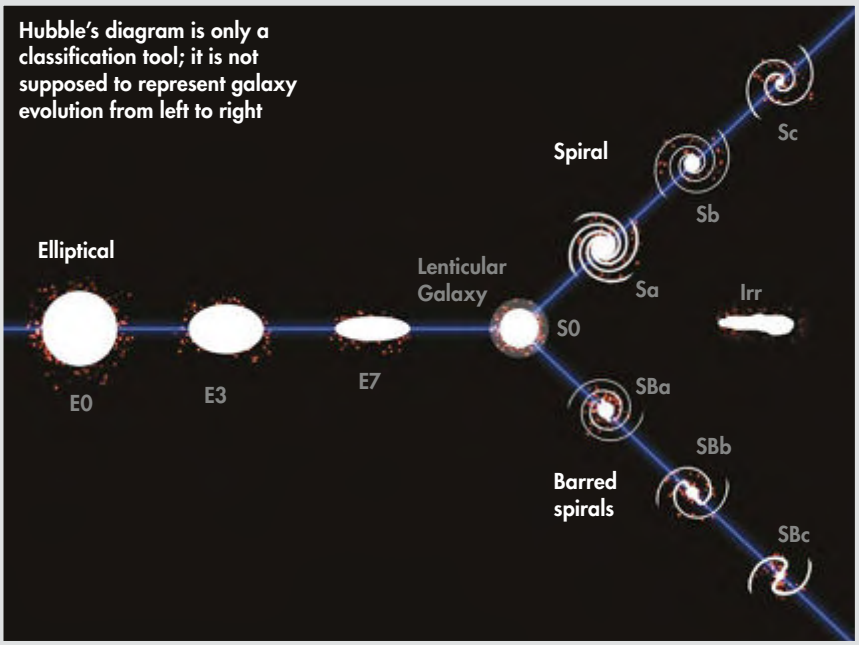
These galaxies are not alone in the Universe and so they frequently bump into each other. Most often there is a notable size difference, and so the small galaxy is simply subsumed into the much larger one. Galaxies that have undergone such a process begin to form dense bulges of older stars at their centres. However, if the two galaxies are around the same size, the process is more dramatic. The merger can take a billion years and pull the galaxies into some strange shapes. These become irregular galaxies. While not all irregulars are undergoing a full merger, they have all interacted with another galaxy and been pulled oddly by gravity.

For those that do merge together completely, the end result is an elliptical galaxy. This is essentially a giant bulge, with stars moving around randomly within it. There is little star formation inside, meaning that only older red stars remain, sometimes leading these galaxies to be called 'red and dead'. There are also lenticular galaxies, that bridge the gap between spiral and elliptical. The theory is that they were once spirals, whose arms have faded away. S

▲ Galaxy mergers occur over billions of years, resulting in the formation of elliptical and irregular galaxies

NASA/ESA AND THE HUBBLE HERITAGE (STSCI/AURA)-ESA/HUBBLE COLLABORATION X 4, © STOCKTREK IMAGES, INC./ALAMY

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s staff writer



HUBBLE'S **TUNING FORK**

When he first began observing galaxies in 1926, Edwin Hubble created a classification system to keep track of them that is still in use today. Because of its shape, it has become known as the Tuning Fork diagram.

Galaxies are separated out into ellipticals and spirals, designated E and S respectively. Ellipticals are numbered according to their roundness, with E0 being almost round and E7 being very elliptical.

The two tines of the fork are created as the spirals are separated out into barred (SB) and non-barred (S) spirals. These are then given a letter depending on how tightly wound their arms are. An Sa galaxy would be a very tightly wound, non-barred spiral, whereas an SBc galaxy would have loosely bound arms jutting from a bar.

Galaxies lying in the central point, dubbed S0, are called lenticular galaxies. These are galaxies with the large bulge and ageing population commonly associated with elliptical galaxies, but which still have some kind of disc structure.

With Mark Parrish

How to

PART 1

Build a tabletop tracking mount

Begin this two-parter by making the arm that holds the camera

Astrophotography takes a lifetime to perfect, but at every stage a little know-how and specialist equipment helps you to progress. This month's project is a simple tabletop mount that can track the apparent movement of the stars, which allows you to increase exposure times and capture more light with your camera. Once the mount is correctly aligned, you simply rotate a drive disc, which keeps your camera pointing at the same spot in the sky.

This well-known design (sometimes called a Scotch mount or a barn door tracker) can be made using materials found in most DIY stores and requires only minimal woodworking skills. In this issue we are going to focus on the construction of the main elements of the mount and the drive rod – you can download printable templates for these from **http://bit.ly/trackingmount**. Next month, we'll cover the drive mechanism and describe how to operate it.

ALL PICTURES: MARK PARRISH

The finished mount will allow you to take astrophotos at longer exposures

Building on the basics

The principle behind the mount is simple. Earth turns one full revolution every 23 hours 56 minutes and four seconds. This period is called a sidereal day. To an observer on Earth the stars appear to revolve slowly around the polar axis – which for the northern hemisphere is very close to the star Polaris in Ursa Minor.

The mount has a hinged upper arm on which the camera is mounted, and the hinge's axis is arranged to point towards Polaris. There is a threaded, curved M6 rod between the arms, and this has the drive disc on it. Turning this disc causes the upper arm (and the camera) to rotate at the sidereal rate. The clever bit is the maths. One full rotation of the disc on the rod causes the arm to move by 1mm. For accurate tracking the centre line of the rod must be at the correct distance from the axis of the hinge – in this case 228.5mm.

If this all sounds a bit technical or tricky to achieve, don't worry, we have also provided a template, which you can use to bend your rod to the right shape, ▸

TOOLS AND **MATERIALS**

TOOLS
Coping saw, drill with bits to suit the screws and rod, sandpaper, ruler, pencil, screwdriver, 10mm spanner or pliers.

MATERIALS
Plywood (12mm thick, fine quality) for the arms and the base, scrap wood for the drive disc gauge.

SUNDRIES
M6 studding (minimum length of 300mm), hinge, six M5x20 bolts and nuts for hinge, seven M6 nuts, two M6x40 bolts, three rubber tap washers.

FINISH
Exterior-quality gloss paint or spray paints for a nice finish.

▲ Consider adding a finish to the wood parts before assembly – it'll be harder to do later on

▸ and the design is quite forgiving of a few inaccuracies. We found that it is easier to bend a whole length of rod by hand, and then choose and cut the best section (you need approximately 200mm) for your mount.

The main parts of the mount are made from strips of 75x12mm plywood, which is easy to cut. Once you have printed out the A4 templates, lightly stick them to the plywood and cut around each shape. The angled tops to the base arms need to correspond to your latitude, which will make polar alignment easier to achieve. We made ours for 51°N; if you are in the UK you will be somewhere in the region of 50°-60°N.

The hinge needs to move smoothly and not have too much 'play'. We found a good quality and inexpensive stainless steel one on eBay, but a reclaimed one from an old door could be a good candidate. While you are shopping you also need a ball joint tripod head, which you will fix to the tracker. This allows you to aim your camera in any direction. These heads require a ¼-20 tpi screw (not M6 – even though the size might look similar) so you can fix them to the mount from below.

Next month we will finish assembly and show you how to add a simple motor drive, but the beauty of a barn door tracker is that it works just as well when hand-driven, and there is something very satisfying about the interaction involved. The drive wheel doesn't need to be turned constantly – just keep the average rate at one turn per minute. We will explain more about how to achieve this in the next issue.

Mark Parrish is a consummate craftsman who loves making astro accessories

ALL PICTURES: MARK PARRISH

GO ONLINE

Download useful drawings, printable templates and plans for this project at **http://bit.ly/trackingmount**

STEP-BY-STEP GUIDE

STEP 1

Use the templates available online to mark out and cut the timber to size. You could even ask your local timber merchant to cut the plywood into 75mm-wide strips for you. All you would then need to do is cut the profiles on each section.

STEP 2

Check the template hole spacing for the hinges and adjust if necessary to suit yours. Use a nail or punch to tap marks into the plywood to aid accurate drilling. We taped both arms together and drilled some holes at the same time.

STEP 3

It is worth spending some time smoothing the parts with fine sandpaper before proceeding. You can also temporarily fit the hinges and enlarge the holes slightly if necessary until the screws fit. After carefully sanding, apply a nice finish. We used spray paints.

STEP 4

Bend the M6 drive rod. We stuck our rod template on a piece of scrap wood and cut this to make a gauge. Bend the rod a little at a time around the gauge. Don't hammer it or the thread will be damaged. Make small corrections until you have enough length.

STEP 5

The rod and hinge are fixed on using M6 and M5 bolts and nuts. The base and arms are joined to lower arm are joined using small wood screws. Countersink the screw heads so they sit flush with the surface, and make pilot hole in the base arms to avoid splitting the wood.

STEP 6

Fix the levelling feet, which are made from M6 bolts passed through holes in the base cross bar. Glue M6 nuts above and below the hole (but be careful not to get glue on the thread) and push a domed rubber tap washer onto the end.

Image processing

An introduction to Levels

With **Ian Evenden**

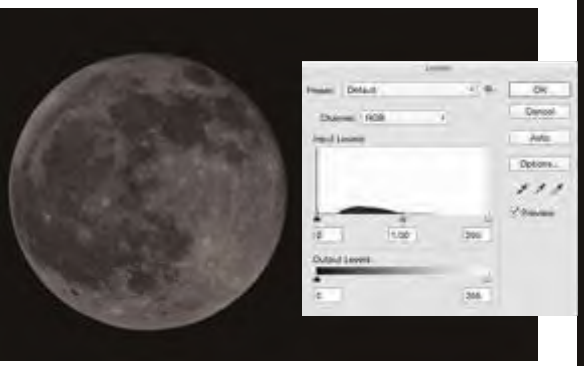
Photoshop has three main tools for adding contrast and bringing out detail. This month we're going to look at the Levels tool, followed by the slightly more complex Curves tool next month. The obvious candidate, Brightness and Contrast, should be ignored as it's a sledgehammer and we need to use a more delicate touch.

Load your image into photoshop and open the Levels tool (**Image > Adjustments > Levels**); this brings up a palette showing a histogram of the image. The adjustment window is the same in full version Photoshop and cut-down Photoshop Elements, and also features in freeware program GIMP.

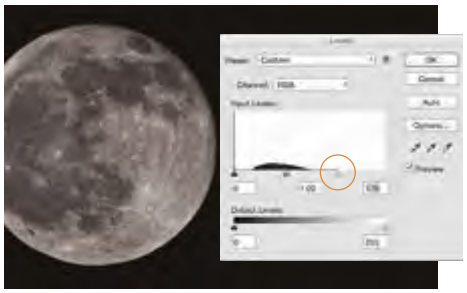
The Levels histogram is identical to the one a DSLR displays, combining the image's red, green and blue channels. The brightness of the pixels runs from left to right, brightest at the far right, while the height of the graph shows the number of pixels at that brightness. On an average photo you would expect a spread of tones across the histogram, with a peak in the middle, but our shot of the Moon is different. It shows a thin high peak in the dark tones (at the extreme left) representing the background sky, plus some midtone data for the Moon itself. As it stands now the image has no really bright highlights, so there are no peaks, and thus no image data, on the right.

Below the histogram are the three sliders used to manipulate the tones in the image. The leftmost sets the black point, where the dark tones merge to pure black. The rightmost does the same for white, the middle one the brightness of everything in between.

ALL PICTURES: IAN EVENDON

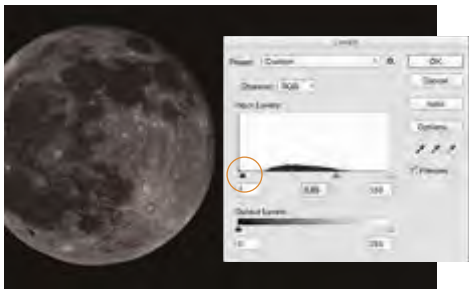


▲ The Levels histogram is similar to that of a DSLR. Three sliders control the tonal balance



▲ Pulling the rightmost slider inwards brightens the lunar surface, but be vigilant of clipping

As we have no highlights data, we can move the right-hand slider to meet the midtone data on the histogram. You'll see the Moon brighten as you do this, but be careful not to push it too far as this will turn the highlights pure white, known as 'clipping' – you can avoid this by holding the Alt key as you move the slider: the image goes dark and clipped areas show up brightly. Hit OK, then open Levels again. As a result of our edits, the midtone data is spread over a wider area of the histogram and image contrast has increased. As there is no detail in the black background, you can use the left-hand slider to darken already dark areas without losing anything. Bring it just inside the peak on the histogram's left and you'll see the Moon's seas darken.



▲ Moving the leftmost slider inside the thin high peak – representing the sky – darkens the seas

The midtone slider can darken or lighten the image. What you're actually doing is changing the definition of mid-grey; for our Moon photo, moving it to the right to emphasise the shadows works well.

By adjusting the image in this way we've made all those lovely lunar seas and craters appear more defined. Nearly every image can benefit from adjustment with Levels; it's a simple but powerful way to tweak your astrophotos.

Ian Evenden is a journalist working in the fields of science, tech and photography

The Moon's craters and seas are better defined by the end of our processing

Scope DOCTOR

With **Steve Richards**

Our resident equipment specialist cures your optical ailments and technical maladies

I have a Sky-Watcher Skyliner-200P Dobsonian and want to upgrade the eyepieces (I only have the ones packaged with it) and mount. What do you suggest?

MIKE BATTY

The Skyliner-200P is a very popular choice, combining a generous 203mm (8-inch) aperture with a 1,200mm focal length and a substantial mount. The supplied 25mm and 10mm eyepieces have the quality typical of eyepieces that come bundled with scopes, and although the 25mm offers a pretty fair performance, the 10mm can be a little disappointing.

Although the theoretical maximum usable magnification of your telescope is 400x, the seeing (a measure of the steadiness of the atmosphere) has a dramatic effect on the magnification that you can sensibly use. Around 200x to 250x is more realistic for typical UK skies, so the shortest effective focal length that you should consider would be 5mm. For a wide field of view, consider BST Starguiders; for a narrower field of view at 6mm, 10mm, 15mm and 20mm focal lengths, the lower cost Vixen NPL Plössls would also be great choices for your scope.

A Barlow lens acting as a 2x multiplier would be an excellent purchase for use on your longer focal length eyepieces. However, don't be tempted to buy a low-cost one: the Tal 2x (if you can find one) or the Baader Classic Q 2.25x Barlow would certainly enhance your eyepiece collection.

As for remounting your telescope, either the Sky-Watcher HEQ5 or Celestron Advanced VX equatorial Go-To mounts would be suitable for your needs.

The Skyliner-200P can easily be upgraded with better eyepieces

STEVE'S TOP TIP

What is the best way to plan the composition of my astrophotography?

Pleasing compositions of celestial objects can be a little difficult to arrange. As many objects are very dim, it's necessary to take a photograph first to check the composition! Luckily, many planetarium programs, including the popular and free Cartes du Ciel, can overlay a rectangle representing the field of view of your camera on top of an image of the object you want to capture. This rectangle can be rotated and moved until you're happy with the virtual framing of the object, and then you can rotate your camera to match this orientation and position to capture your image.

I have a Celestron AstroMaster 130EQ but find the tripod flimsy and the mount bulky. Can you suggest a more robust alternative?

SIMON JONES

The Celestron AstroMaster 130EQ is an excellent telescope for beginners but, without a doubt, the sturdier the mount, the better the view. Even the simple act of focusing the telescope can cause the view through the eyepiece to shimmer and shake. A heavier mount will dampen down these vibrations much more quickly than a lightweight one.

If you are finding the mount rather cumbersome you may wish to consider an altaz mount such as the Sky-Watcher AZ4 Alt-Az or Vixen PORTA II. However, keep in mind that although both are more stable than your existing mount, to follow objects across the sky you will need to adjust both the horizontal and vertical axes at the same time.

If you'd prefer to stick with an equatorial mount, then either the Celestron Omni CG-4 or Sky-Watcher EQ5 Deluxe mounts would also be compatible with your telescope, but are more robust than the standard mount supplied. All four are packaged with tripods.

A simple change of mount will give the AstroMaster 130EQ a performance boost

PAUL WHITFIELD X 2

Steve Richards is a keen astro imager and an astronomy equipment expert

Email your queries to scopedoctor@skyatnightmagazine.com

Sky at Night MAGAZINE

Reviews

Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

Each category is given a mark out of five stars according to how well it performs. The ratings are:

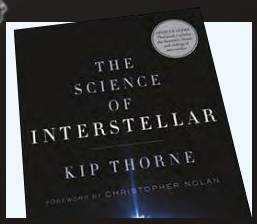
★★★★★ Outstanding
★★★★½ Very good
★★★★☆ Good
★★½☆☆ Average
★½☆☆☆ Poor/Avoid

90

A new challenger enters the DSLR-dominated camera market

SEE INTERACTIVE 360° MODELS OF ALL OUR FIRST LIGHT REVIEWS AT WWW.SKYATNIGHTMAGAZINE.COM

This month's reviews



First light

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Gear

104 Including this 100° apparent FOV eyepiece

Find out more about how we review equipment at **www.skyatnightmagazine.com/scoring-categories**

FIRST **light**

See an interactive 360° model of this camera at **www.skyatnightmagazine.com/Sonya7S**

Sony α7S mirrorless interchangeable lens camera

SKY SAYS... Amplification is a headline act of the α7S, with an incredible ISO range of 50 to 409600

A worthy challenger in the DSLR-dominated camera market

WORDS: PETE LAWRENCE

VITAL STATS

- **Price** £2,049 (body only)
- **Sensor** Full frame 12.2 megapixel Exmor CMOS
- **ISO range** 50 to 409600 for stills; 200 to 409600 for video
- **Size** 126.9x94.4 x48.2mm
- **Weight** 489g (including battery and storage card)
- **Supplier** Sony
- **www.**sony.co.uk
- **Tel** 020 7365 2413

On paper, the specifications of the Sony α7S may make you sit up and pay attention, especially as many of its capabilities also look good for astrophotography. The α7S is a category of camera known as a MILC: a mirrorless interchangeable lens camera. MILCs have been around since 2004, and are similar to DSLRs in that you can change their lenses and directly attach them to telescopes with an appropriate adaptor. The biggest difference is that they don't have a reflex flip mirror for viewing what's coming through the lens. Instead, they monitor what the sensor is seeing and display this either on the camera's rear screen or in an electronic viewfinder.

The lack of flip mirror removes a fair amount of bulk from the camera's design. Compared to its DSLR rivals, the α7S's dust- and damp-resistant body looks rather petite, distinguished and, dare we say it, elegant. Inside, the α7S packs a full frame (35mm) sensor containing a modest 12.2 megapixels.

Many high-end cameras break the 20-megapixel barrier and this may cause you to think the α7S is tame by comparison. But for astrophotography, this is a good thing. The lower pixel density means that individual light collecting photosites are larger. For a given amount of light, larger photosites individually collect more photons than smaller ones. More photons mean a stronger signal and an improved signal-to-noise ratio. The content of each photosite is read and amplified according to the gain, or ISO setting. As both signal and noise are amplified together, keeping the signal-to-noise ratio high helps make noise less intrusive.

Ultra amplified

Amplification is a headline act of the α7S, the camera boasting an incredible ISO range of 50 to 409600. Top-end values aren't known for their finesse and the α7S doesn't break that rule, but the mid-levels are interesting. The technical implementation of ISO within a camera produces more noise and smaller tonal range at high ISO values. It's the job of the camera's image processor, called BIONZ X, to clean the images as best it can without losing or adding detail.

Our tests with low to mid-range ISOs were very positive, with plenty of strong detail being seen with generally low noise. We stacked an image of comet C/2014 Q2 Lovejoy, which was on display during the review period, and the camera managed to pull out the comet's colour and faint, delicately structured tail with ease. ▸

SCALING THE HEIGHTS OF ISO

The α7S's extensive ISO range of 50 to 409600 is vast. The highest values create images of understandably questionable quality, but the middle values are good. A test sequence of Orion's Sword showed that you could use shots up to ISO 51200; great news if you are using a fixed tripod or don't have the best mount tracking accuracy. At high ISO, exposures can be kept short to avoid trailing. However, it must be stated that best results are had using lower ISO values with accurately tracked long exposures.

Higher ISOs really come into their own for focusing a region of sky devoid of bright stars; the camera's live view is simply superb at high ISO. The higher mid-range ISOs are also ideally suited to capturing fast moving events such as quickly shifting displays of the aurora and the rapid changes that occur at the critical stages of a total solar eclipse. They are also perfect for killer untrailed shots of the Milky Way over beautiful foreground scenery.

LENSES AND LENS ADAPTORS

Sony produce a range of lenses and lens adaptors compatible with the α7s. These include (left to right) the 70-400mm G SSM II, Vario-Tessar T* FE 16-35mm ZA OSS, Vario-Sonnar T* 24-70mm ZA SSM and LA-EA4 35mm full-frame A-mount adaptor.

CONTROL CLUSTER

The α7S's controls are clustered on one side of the camera. Three primary dials give access to ISO, f/number and exposure settings quickly and efficiently. However, the shutter button lacks a tactile half-press feedback. It is too easy to think you're half-pressing to get an exposure reading, only to find you're actually taking a shot.

ARTICULATING LCD SCREEN

This 3.0-inch TFT LCD screen provides the main interface to the camera's functions. Fine detail is beautifully presented on this 912,000-pixel display. The screen can tilt up and down but not from side to side. Move your eye to the viewfinder and the LCD turns off, switching the display to the internal XGA OLED screen.

MIRRORLESS DESIGN

The α7S uses a uses an electronically controlled, vertical-traverse, focal plane type shutter (1/8000-30 seconds, plus bulb). This can be disabled, turning control over to a purely electronic shutter (silent shooting). The lack of a reflex mirror in the MILC design also removes the issue of mirror-shake, which can sometimes occur when taking a shot with a DSLR.

SONY E-MOUNT

The α7S natively uses E-mount lenses, but commercial adaptors are available that allow other manufacturer's lenses to be used with the camera. An inexpensive E-mount to T-thread adaptor is required for telescope coupling.

FIRST **light**

LENS NOT SUPPLIED

WI-FI

A built-in Wi-Fi and near-field communications option allows you to control the camera with a smartphone or similar. Paid-for apps can also be downloaded to the camera to add functionality: current offerings include apps to automate star-trail production, give timelapse facilities and auto-upload to a Flickr account.

The Orion Nebula at ISO 400, 300-second exposure

SKY SAYS...
Now add these:

1. Suitable Sony E-fit 'fast' lens
2. Sony Alpha T-Ring
3. Sony A to E mount adaptor

▸ Single shots of Orion's Sword at progressively higher ISOs seemed to suggest that ISO 6400 or 12800 was perfectly usable. Stretching an image, background noise starts to become noticeable higher than this, but acceptance is down to personal taste. Image quality above ISO 51200 seemed drop off quite rapidly.

We were very impressed with the α7S's capabilities for astrophotography: it promises great things when it comes to meteor showers, aurorae and wide-field Milky Way imaging. But bear in mind that this is still a general purpose camera, not one optimised for astro imaging. Consequently, the sensor's infrared-blocking filter cuts out some of the red hydrogen-alpha light emitted by many deep-sky objects, rendering them slightly too magenta or blue. Sadly, for astronomical purposes, this lost the camera a point for imaging quality. If Sony were to bring out an astro-modified version, an equivalent to Canon's 60Da, it would be a different matter altogether. While performing our tests, we also noted that the rear LCD screen glows when a long exposure is taking place. We could see no purpose to this and couldn't find any way to turn it off.

▾ We were pleased to capture some of the faint detail of comet C/2014 Q2 Lovejoy's tail

WWW.THESECRETSTUDIO.NET, ISTOCK, PETE LAWRENCE

Smart control

The camera can connect to other devices via its in-built Wi-Fi or, if you have one, a near-field communications device. This would allow you, for example, to control the camera and review any pictures you take via a smartphone. It's worth noting that you can also record videos in either full HD or even 4K with additional kit. The ISO range for video work is 200 to 409600. This means that you could, for example, wax lyrical in a piece to camera under the stars, with many of them making an appearance in the video too.

What we really liked about the α7S was the way it got our creative side working. It was exciting to experiment with and overall great fun to use. It's also good to see another serious contender enter the DSLR-dominated astrophotography field – even if it's not strictly a DSLR. S

VERDICT

BUILD & DESIGN	★★★★½
CONNECTIVITY	★★★★★
EASE OF USE	★★★★★
FEATURES	★★★★★
IMAGING QUALITY	★★★★½
OVERALL	★★★★★

FIRST **light**

See an interactive 360° model of this scope at **www.skyatnightmagazine.com/CelestRASA**

Celestron 11-inch Rowe-Ackermann Schmidt astrograph

A four-element lens group helps this imaging scope deliver stunning astrophotos

WORDS: PETE LAWRENCE

VITAL STATS

- **Price** £3,149
- **Optics** Rowe-Ackermann Schmidt design
- **Aperture** 279mm (11 inches)
- **Focal length** 620mm (f/2.22)
- **Focuser** Dual 10:1 Feather Touch
- **Extras** M42 (T thread) and M48 adaptor plates, battery pouch for cooling fan
- **Weight** 19.5kg
- **Supplier** David Hinds
- **www.**celestron.uk.com
- **Tel** 01525 852696

WWW.THESECRETSTUDIO.NET X 5

Celestron's Rowe-Ackermann Schmidt astrograph (RASA) is designed specifically to photograph the wonders of deep space. The formal definition of an astrograph is a telescope designed for the sole purpose of astrophotography, and this instrument certainly fits the bill. Dividing its 620mm focal length by its 279mm (11-inch) aperture identifies this as a fast f/2.22 instrument.

The astrograph is moderately heavy, with a single carry handle at the rear of the tube; for mounting, we'd recommend you enlist an extra pair of hands. Where you'd possibly expect an eyepiece holder, there's a 12V MagLev cooling fan protected by a dust filter. Cameras connect to a threaded cylinder on the front, which protrudes through the corrector plate. This is a similar arrangement to the Hyperstar adaptors used on certain Schmidt-Cassegrains, although the RASA is a redesign rather than simply a Hyperstar Schmidt-Cassegrain itself.

The threaded cylinder also houses a four-element lens assembly, which is protected behind an optical window. The window can be replaced by a filter, though the only alternative at the time of writing seems to be a £619 light pollution filter. On the subject of the corrector plate, it's also worth investing in a portable 12V hair dryer, because large pieces of glass like this are prone to misting up on damp UK nights.

SKY SAYS...
The stars were sharp across the entire field and showed no serious distortion right to the frame corners

M42 (T thread) and M48 adaptors are provided, both attaching via a screw-on collar. The collar's thread is long and it takes a lot of turns to secure it fully. You also need to be careful not to touch the corrector while doing this. Collimation screws are presented on the four-element lens assembly and slots in the camera adaptor plates give you surprisingly good access to them.

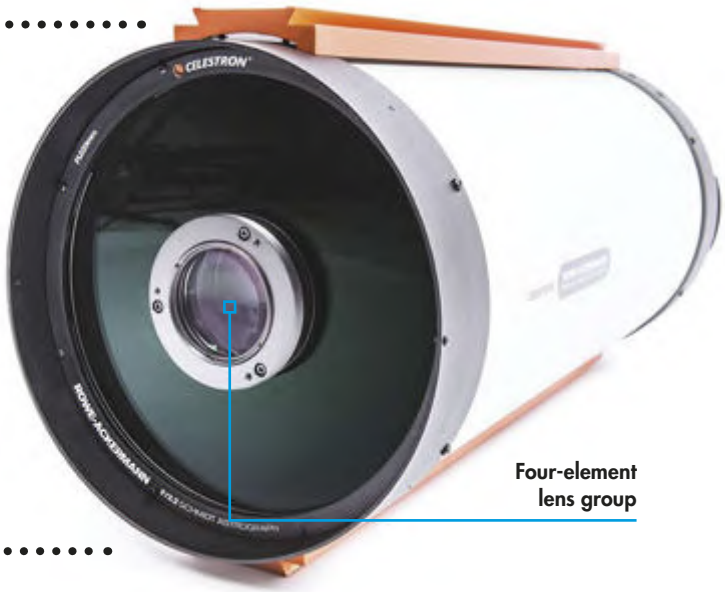
The ideal camera is...

The best camera to use with this scope would be a CCD with a low circular profile, so that it is completely hidden behind the adaptor plate. However, DSLRs are perfectly okay to use too, and they do not have any significant effect on the resulting image. The use of a mono CCD camera requires filters to produce colour images, but too large a filter wheel will start to block light. One solution would be to use interchangeable slot drawers, several of which can be bought separately. ▸

A DESIGN THAT MIMICS FILM

Schmidt astrographs were common in the days of film astrophotography, but the film used had to be specially curved in the focal plane of the instrument to maintain sharp stars from corner to corner of the photograph. But the RASA works with the flat digital imaging sensors found in modern cameras, and it is not uncommon to find that some of these now exceed the original dimensions of 35mm film.

Amateur astronomers Dave Rowe and Mark Ackermann, both experts in optics, came up with a telescope design which could emulate the curved film performance of early Schmidt astrographs with flat, digital sensors. It's the four-element, rare-Earth glass lens group that performs the optical magic that makes this telescope such a marvel. After passing through the Schmidt corrector plate, reflecting off the large primary mirror and passing through the four-element lens group, the resulting image is flat and distortion free to each corner of the imaging frame. Stars remain pin sharp and the superb resolution of this large aperture instrument is maintained throughout the photograph.



Four-element lens group

FAST LIGHT BUCKET

The generous 11-inch aperture and fast f/2.22 focal ratio delivers a bright image. Consequently, deep images of delicate celestial objects can be achieved in relatively short exposures. In addition, the 11-inch aperture provides a 0.5-arcsecond resolution. This compares extremely favourably with the 1.36-arcsecond resolution provided by a 4-inch apochromatic refractor, for example.

ADAPTOR PLATES AND FITTING COLLAR

Cameras are attached to the front of the telescope via an adaptor plate. M42 (T thread) and M48 plates are included as standard, and these are secured in the centre of the corrector by a screw-on collar. Unscrewing the collar slightly allows you to rotate the camera for better framing.

COOLING FAN

The 12V MagLev fan helps to cool down the inside of the telescope so it matches the outside environment. This helps to reduce unwanted internal air currents, which could otherwise blur the fine resolution this instrument is capable of. The fan and air vents are protected by dust filters.

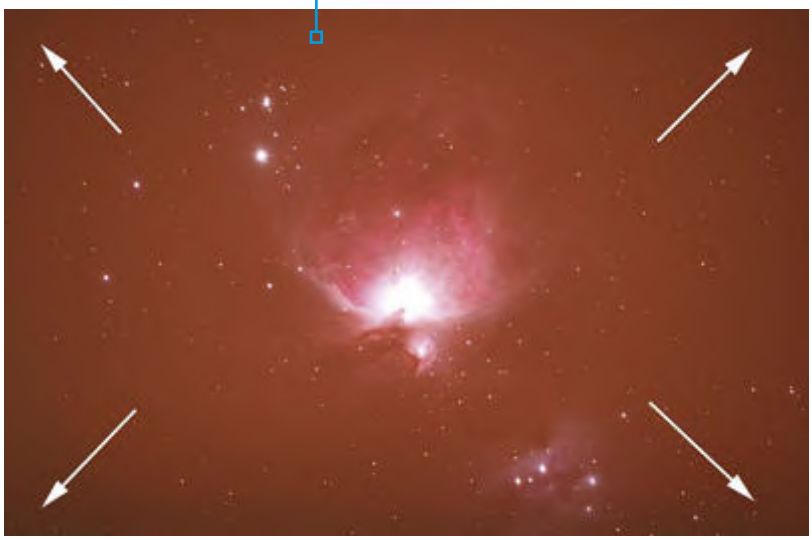
FOCUSER

The 10:1 Feather Touch focuser offers course and fine focusing. With an adaptor ring fitted, back focus travel is 55mm. The focuser action is smooth thanks to a linear brass bearing. Mirror locks are available to avoid mirror flop, which otherwise might occur during a long session.

FIRST **light**

LARGE IMAGE CIRCLE

The telescope's focused image circle gives full illumination over an area 70mm in diameter. This means that vignetting is minimised even across a full frame (35mm) DSLR sensor or the largest CCD sensors typically used by amateurs. Camera bodies themselves may create a small element of corner shading, but flat-fielding takes care of this.



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SKY SAYS...
Now add these:

1. Light pollution filter for Rowe-Ackermann astrographs

2. CGE Pro computerised mount

3. Nightscape 8300 CCD camera

▸ Two Losmandy-style dovetails run the full length of the telescope tube. One is for mounting the tube itself, while the other allows you to attach accessories such as an autoguider. The RASA comes without a finder and this is an important initial add-on to get.

If you plan on using a DSLR, it's necessary to tether the camera to a laptop positioned near the focus end of the scope. It's impossible to turn the focus knobs and properly review what's happening on the camera's rear screen without this arrangement.

Taking on a refractor

The astrograph's performance was extremely good. Using a DSLR with an APS-C sensor, the scope gave us a measured field of view of 1.6x2°. We found our images went deep very quickly, a five-second test at ISO 1600 showing a tremendous amount of detail in and around the Orion Nebula, M42. The billowing nebula had lots of fine structure in it and this was even more impressive when we compared the shot with a similar field taken by a 4-inch apochromatic refractor. The larger aperture of the RASA really delivered a tremendous improvement in resolution. The stars were sharp across the entire field and showed no serious distortion right to the frame corners. The four-element lens group in the centre of the corrector really did its job well; the quality of the field was quite superb.

It initially took us a few moments to figure out that the images taken were mirror-reversed left to right. This is an easy to fix once identified, but it's something to be aware of. Using a mono filtered CCD camera we did experience some odd concentric reflections around really bright stars. This wasn't a problem with our DSLR camera.

Short tube refractors tend to rule by majority when it comes to wide-field deep-sky imaging. Such setups have many virtues, including cost, portability and ease of use. Although expensive, what you're paying for with the RASA is the resolution and finesse of the final delivered image. This is something it does extremely well. S

Our shot of the Orion Nebula at ISO 1600, five-second exposure

VERDICT

BUILD & DESIGN	★★★★½
EASE OF USE	★★★★½
FEATURES	★★★★½
IMAGING QUALITY	★★★★★
OPTICS	★★★★½
OVERALL	★★★★★

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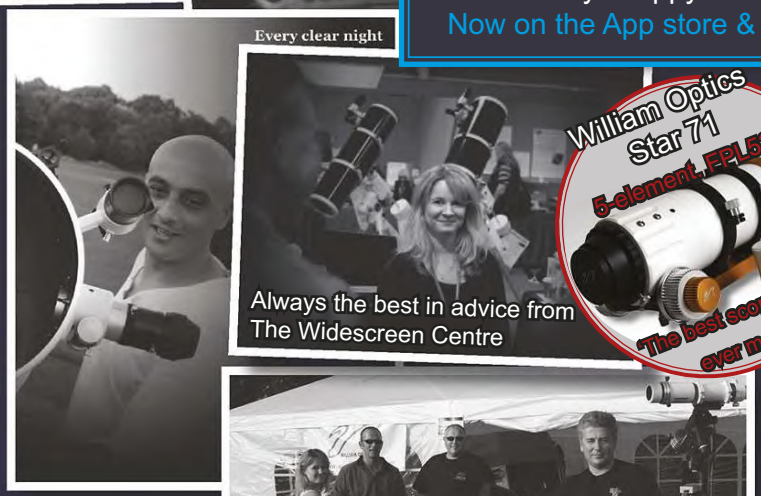

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Lunar photo by Widescreen customer Richard Maun. Main BSIA image by Tom Kerss. Sadr nebulosity by Geoffrey Lenox-Smith

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FIRST **light**

See an interactive 360° model of this scope at **www.skyatnightmagazine.com/VixED81SII**

Vixen ED81SII 3-inch apo refractor

A portable starter scope that can be used for both imaging and observing

WORDS: PAUL MONEY

VITAL STATS

- **Price** £1,077 (£949 tube only)
- **Aperture** 81mm (3.18 inches)
- **Focal length** 625mm (f/7.7)
- **Optics** ED multicoated objective
- **Focuser** Dual-speed 7:1 reduction
- **Length** 585mm
- **Mounting** Tube rings with dovetail bar
- **Weight** 3.5kg (tube only 2.3kg)
- **Extras** Flip mirror diagonal, red-dot finder, carry handle
- **Supplier** Vixen UK/Opticron
- **www.**vixenoptics.co.uk
- **Tel** 01582 726522

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Refractors continue to be a popular choice both for visual and imaging purposes, and this is especially true of short focal length models. Continuing this trend, Vixen has upgraded its successful ED81S with higher-quality glass and added a dual-speed focuser, resulting in the ED81SII. The telescope can be purchased as a standalone tube, or packaged with a Vixen flip-mirror diagonal and red-dot finder. It is the latter we are reviewing here.

The telescope tube is 585mm long and has a diameter of 90mm, while the optical system consists of a 3.18-inch multicoated objective lens with a focal length of 625mm. This gives a short focal ratio of f/7.7. The objective lens uses ED (extra low dispersion) glass to remove the effect of chromatic aberration or colour fringing.

The focuser offers dual-speed fine control with a 7:1 ratio, which is particularly useful for astrophotography. The focus can also be locked using a tension knob, reducing the chance of image shift if your photographic equipment is on the heavy side. For the price we would have liked to have seen a graduated scale to make it easier to return to the same focal point in subsequent sessions.

SKY SAYS...
Our star test was pin sharp and crisp; only the slightest distortion appeared at the field's very edges

The end of the focuser terminates in a 60mm thread with a 2-inch adaptor screwed into it; in order to use the scope for visual observing, you need to attach a star diagonal or the optional flip mirror diagonal. If using the flip mirror diagonal, you can unscrew the straight-through end barrel to reveal an M42 thread, to which you can attach a T-ring adaptor for prime focus astrophotography.

Crisp and clear

For our visual tests the supplier loaned us a range of Vixen SLV 1.25-inch eyepieces, including 25mm, 12mm and 6mm variants. With the 25mm eyepiece the system gave 25x magnification, providing a wide field of view that allowed us to take in the whole of the Sword of Orion in one go. Our star test using Capella in Auriga was pin sharp and crisp across almost the whole view; only the slightest distortion appeared at the very edges.

At 25x magnification the Moon was also crisp, with little in the way of colour fringing around its bright edge. Higher magnification brought out plenty of sharp detail so we swung the scope to point at Jupiter and were rewarded with a small – but nicely detailed – disc with the two main belts and the Great Red Spot on display. ▸

LIGHTWEIGHT GET UP AND GO SETUP

The ED81SII tube alone is quite lightweight at just 2.3kg, so easily manageable. With its carry handle it is simple to pick up one-handed. Being so light it can easily be used with any of the many tracking mounts designed for small scopes we've reviewed in recent years, making it a nice portable system for imaging and observing from a remote site. Adding the red-dot finder, flip mirror diagonal, tube rings and dovetail bar only brings the weight up to 3.5kg, again nothing that would press a good tracking mount. This system could be taken on holiday as hand luggage, making it an ideal instrument for eclipse trips, providing of course you also have a certified solar filter for the front end. Just add a mount and at least two eyepieces and you'll have a good setup that should give plenty of enjoyment for many years.

FOCUSER

The focuser is of a dual-speed rack and pinion design with a 7:1 ratio for providing fine focus control. It can accommodate a 2-inch diagonal or the optional flip mirror diagonal. It also features a generous 93mm of focus travel.

FLIP MIRROR DIAGONAL

The flip mirror diagonal allows the use of two 1.25-inch eyepieces, which you can switch between by turning a knob – this is useful for comparing low- and high-magnification views. Unscrewing the end barrel reveals an M42 thread, allowing a T-ring adaptor to be attached for prime focus astrophotography.

DEW SHIELD

The dew shield is of a fixed design; it cannot be retracted, but it can be unscrewed from the main tube should you need to access the objective lens. The shield gave good protection from dewing up under normal conditions and did a good job at cutting out extraneous light as well.

TUBE RINGS AND CARRY HANDLE

The tube rings are nicely crafted, provide good support for the telescope and allow easy rotation of the tube assembly if required. They attach to a standard Vixen dovetail bar. A very useful carry handle makes it easy to pick the telescope up and secure it to a mount.

FIRST light

OPTICS

The objective lens is multicoated and made from ED (extra low dispersion) glass to correct for chromatic aberration, also known as colour fringing, where not all colours are brought to the same focus. This was well controlled visually. Photographically there was a little colour fringing on the brightest stars, but nothing too serious.

▸ looking farther afield, we enjoyed a wide view of the Sword region of Orion, with M42 at its heart. It was gratifying to be able to increase the magnification to show the four Trapezium stars. The galactic pair of M81 and M82 in Ursa Major were also well seen, with M82 appearing a little disturbed along its length. M45, the Pleiades open star cluster, filled the view, with a hint of the Merope nebulosity also visible.

We attached our Canon EOS 50D, which has an APS-C sized sensor, via a T-ring adaptor screwed to the body of the flip mirror, and took a series of exposures of several objects including the Pleiades, Sword of Orion and the Moon. We were gratified to capture some pretty sharp images, with only a slight distortion towards the field edges of the stars, something that a quick test shot using our own flat-field corrector easily fixed; it depends on how pernickety you are with respect to the quality of the stars at the image edges as to whether you wish to use a corrector or not.

The ED81SII was easy to set up and install on our Go-To mount and we found it a pleasure to use being so lightweight. It's easy to recommend it for both visual and imaging purposes. S

SKY SAYS...
Now add these:

1. Vixen SX2 mount

2: 25mm SLV Eyepiece

3: T-mount/ring for DSLR camera

◂ We managed to capture a hint of the nebulosity running through M45 in this stack of 21 two-minute exposures at ISO 2000

◂ Our close companion gave up plenty of sharp detail after processing; this is a stack of 32 1/500-second exposures at ISO 100

VERDICT

BUILD & DESIGN	★★★★☆
EASE OF USE	★★★★★
FEATURES	★★★★☆
FIELD OF VIEW	★★★★☆
OPTICS	★★★★☆
OVERALL	★★★★★

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Books

New astronomy and space titles reviewed

RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

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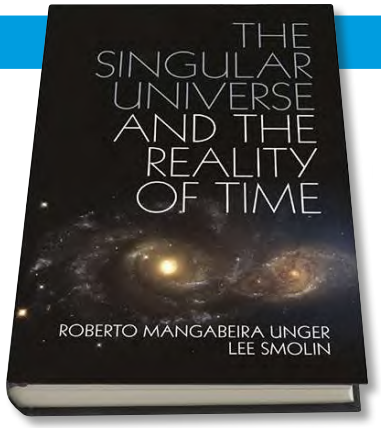
The Singular Universe and the Reality of Time



Roberto Mangabeira Unger and Lee Smolin
Cambridge University Press
£19.99 ● HB

Research that probes the frontiers of knowledge in physics and cosmology conjures bizarre multidimensional terrains on both very small and very large scales. Couched in tortuously difficult mathematics, the leading theories offer few, if any, predictions that can be tested with currently available experimental apparatus. So what if they're all wrong?

Philosopher Roberto Mangabeira Unger and physicist Lee Smolin argue just that in *The Singular Universe and the Reality of Time*. In its 500 dense pages, they put forth their case that research into fundamental physics and cosmology has lost its way, and offer what they describe as a "radical solution" built on the assertions that there is only one Universe and that nothing in it can exist outside of time. These statements may seem like nothing more than common sense, but they are at odds with mainstream interpretations of 20th-Century physics and, when considered fully in that context, require a new conception of the limits of mathematics in describing natural reality.

The published manuscript is the result of eight years' collaboration, but it is not co-written. Instead, the full argument of the book is presented first by Unger as a 350-page discourse in natural philosophy and then by Smolin in a manner which, while still philosophical in nature, connects more directly to established scientific debate. While continually, indeed often repetitively, grounded in their key assertions, the discussion reaches into the past to examine those assumptions' philosophical and scientific legacy and considers their context and implications across a range of disciplines.

Unger and Smolin argue that it's time for a new approach to cosmology

The questions posed by this book are both fundamental and fascinating. Is it sensible to believe we can apply our locally derived understanding of physics to the Universe as a whole, over all of its history? Unfortunately, the authors have explicitly not framed their ideas to make them accessible and much of the substance of their reasoning will be frustratingly impenetrable for readers not already well-versed in both philosophy and theoretical physics.

★★☆☆☆

OLIVIA JOHNSON *is an astronomer who specialises in science education*

Reader price £17.99, subscriber price £16.99
P&P £1.99 Code: S0415/1 (until 25/05/15)

ISTOCK

TWO MINUTES WITH LEE SMOLIN

What inspired you to write the book?
Eight years ago Roberto and I met and discovered that we had each come, from different backgrounds, to similar views about the necessity for the laws of physics to evolve on a cosmological scale. One reason is the necessity that if the choice of the laws that govern our Universe is to be understood, it must be in terms of a process by which the laws evolve.

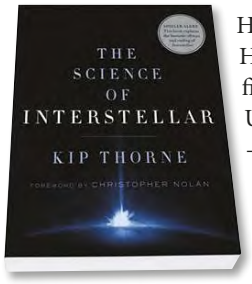
What's wrong with our present understanding of time?
Fundamental physics and cosmology are in a crisis, as can be seen in the surprising results of the Large Hadron Collider and cosmic microwave background observations. We argue that the reason is that current theories treat time incorrectly as a secondary, emergent phenomena rather than as fundamental. We need to explain how the laws of nature were chosen by the Universe.

Is it important to juxtapose physics with philosophy?
Big questions such as the nature of time have been studied for centuries, and philosophers are educated to reflect critically and creatively on the history of thought about deep problems. This makes their expertise uniquely useful to physicists, who are educated with a narrow focus on current ideas and trends. I have found that the ideas of great philosophers such as Gottfried Wilhelm Leibniz and Charles Saunders Pierce are extremely helpful for thinking carefully about the problems science faces now.

LEE SMOLIN *is a senior faculty member at the Perimeter Institute for Theoretical Physics in Canada*

The Science of Interstellar

Kip Thorne
WW Norton & Co
£14.99 ● PB



How much of Hollywood science fiction is science fact? Usually, not much – though that doesn't normally matter. But the fiction is often wrapped around a kernel of scientific fact, and this book explores the factual kernel of the 2014 movie blockbuster *Interstellar*.

US theoretical physicist Kip Thorne was the film's scientific adviser, and here he explores what possible explanations there could be for some of the weird and wonderful phenomena seen in the film, from kilometre-high tidal waves to gravitational time dilation and tesseracts. He uses a combination of real theoretical physics, educated guesses and unabashed speculation, while leaving room for some artistic licence at the same time.

It could be argued that this is all a bit backwards, taking what is clearly fictional and trying to squeeze some science out of it, but it's an interesting way to delve into the subject. Whether it's exploring warped space-time or delving into the heart of a black hole, this book doesn't hold back on anything in terms of concepts. There are no apologies made for this – the text can be hard going, and is not for the uninitiated. But it's also free of maths, and includes clear diagrams, even though some do take a bit of thinking about.

There are times when the first-person tone, unusual in a book about physics, is a little jarring, but at least it helps highlight that this is one (very well qualified) person's take on the subject. It's clear that a lot of thought went into writing the film – and it takes almost as much to read the book.

★★★★☆

CHRIS NORTH *is the UK's Herschel outreach officer*

Reader price £13.99, subscriber price £12.99
P&P £1.99 Code: S0415/2 (until 25/05/15)

How to Build a Universe

BOOK OF THE MONTH

Ben Gilliland
Philip's
£17.99 ● HB

Explaining the origins of the Universe and everything within it in just over 200 pages may sound like a tall order, but it's a challenge for which Ben Gilliland is eminently suited. As writer and illustrator of the *Metro* newspaper's MetroCosm section for the past 10 years, he's faced the challenge of distilling complex ideas from the cutting edge of science into compact features on a weekly basis.

Similarly, Gilliland's *How to Build a Universe* isn't shy about tackling its subject at a lick. Aside from an introductory gallop through the historical background to modern cosmology, the book begins with the Big Bang, then considers the fundamental particles and forces that have governed the Universe's evolution in the intervening 13.8 billion years. From there it's onto the physics of stars, the origins of galaxies and the supermassive black holes at their hearts, and the birth of planetary systems like our own. Finally, the book returns to the bigger picture, with a look at the potential fates of the cosmos, the implications of dark matter and dark energy, and the possibility of universes beyond our own.

Gilliland's text is engaging and authoritative throughout – though it may be a little informal for some – but it's the graphics that really make the book stand out, putting across complex ideas at a glance, including many that this reviewer had never seen tackled before. It's rare these days to see a book packed with so many illustrations, but they make this title a perfect introduction to the origins of the cosmos.

★★★★★

GILES SPARROW *is a science writer and a fellow of the Royal Astronomical Society*

Reader price £16.50, subscriber price £15.50
P&P £1.99 Code: S0415/3 (until 25/05/15)

Stories in the Stars

Susanna Hislop
Hutchinson
£20 ● HB

This is a beautiful book: from its cover, to its illustrations, to its prose. A book in praise of the night sky, it is about retelling and in places reimagining stories the stars have inspired. Many of the stories here have been told for thousands of years, others are completely new.

The book's structure reminded me of Michael E Bakich's *Cambridge Guide to the Constellations* in its systematic review of every official constellation in alphabetical order, from Andromeda through to Vulpecula. This, however, is more story than reference, a delight to read for both the beginner and the well-seasoned stargazer.

Author Susanna Hislop brings to life not only the characters from ancient Greek myth, but the later inventors of the constellations of the southern sky. I liked, for example, the descriptions of the "literal-minded Lacaille" and of Hevelius who "was not the most modest of men". Elsewhere, where no particular myth or legend exists, Hislop makes up her own stories, of children squabbling (Monoceros) or a little girl drawing mermaids (Piscis Austrinus).

My only slight criticism is with regard the layout. Where the illustrations fill a single page, they look lovely; when they are stretched across two, however, much gets lost in the crease, which is quite a shame. Otherwise, this is a beautiful book and a joy to read.

★★★★★

EMILY WINTERBURN *is the author of* Stargazer's Guide

Reader price £16.99, subscriber price £15.99
P&P £1.99 Code: S0415/4 (until 25/05/15)

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

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5 Meade 5000 Mega Wide-Angle 5mm Eyepiece

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WHAT I REALLY WANT TO KNOW IS…
Is there a recipe for an Earth-like planet?

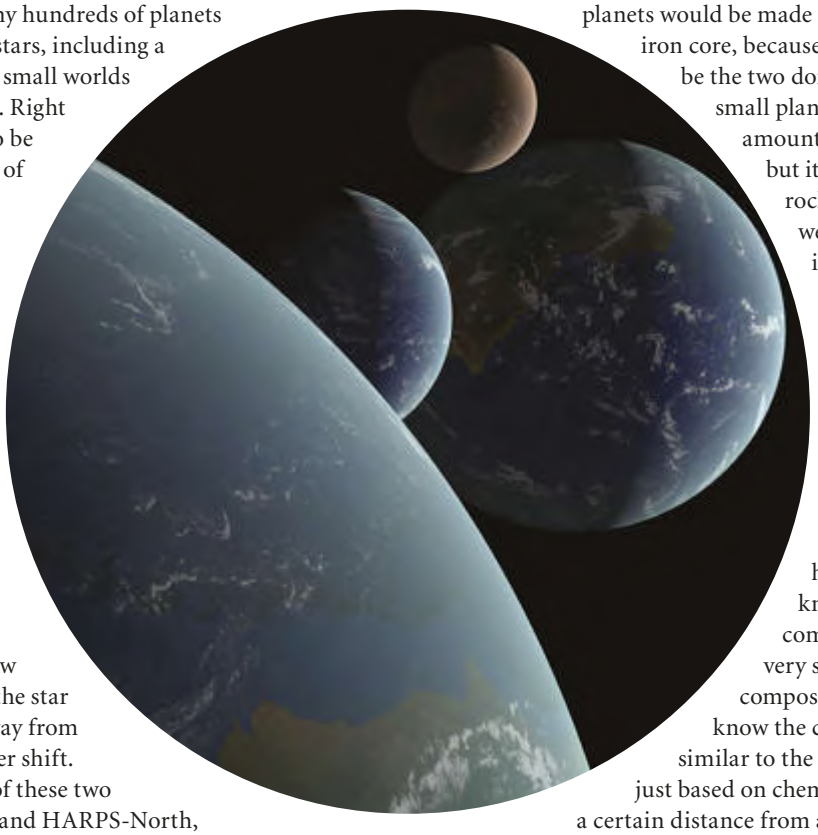
Courtney Dressing is finding that small rocky worlds beyond our Solar System contain a remarkably similar list of ingredients

INTERVIEWED BY PAUL SUTHERLAND

NASA's Kepler space telescope has discovered many hundreds of planets orbiting other stars, including a large sample of small worlds with well-determined sizes. Right now we're just beginning to be able to measure the masses of all these planets.

We're doing so by using instruments like the HARPS-North spectrograph on the 3.6m Telescopio Nazionale Galileo on the Canary Island of La Palma. HARPS-North is based on the original HARPS at the European Southern Observatory in Chile – it stands for High-Accuracy Radial Velocity Planet Searcher. It splits light up into a rainbow and checks to see whether the star is moving towards us or away from us, what's called the Doppler shift.

By combining the work of these two astronomical tools, Kepler and HARPS-North, we've been able to open up a new region of space research that tells us more about the composition of the new-found exoplanets.



The team extrapolated that worlds around 1.5 times the size of Earth should have a similar composition to our planet

Even with planets, size matters

We compared 10 known exoplanets with accurately measured masses and diameters less than 2.7 times that of Earth. We found that planets smaller than about 1.6 times the size of Earth are consistent with being made from the same 'recipe' as our home – they seem to contain the same basic ingredients. That suggests that our Earth is not as special as we might have thought.

It gives us a good rule of thumb for trying to figure out which planets could be habitable and which one probably aren't. So if we were to find two planets around nearby stars, one that is two times the size of Earth and the other 1.5 times the size, and we had to pick just one of those planets to study in more detail, we would probably pick the one that's 1.5 times bigger. That one is more likely to be truly Earth-like.

We worked on the basis that these smaller planets would be made up of a rocky mantle and iron core, because we know those should be the two dominant ingredients in small planets. There is a small amount of water in the Earth, but it is tiny compared to the rock and iron content. So we tested what ratio of iron to rock we needed to explain the mass and radii of the planets we measured, and we found that the ratio we needed was the same ratio you would use to describe the Earth.

From theories of how planets form, we know that the rock composition should be very similar to the rock composition of the Earth. We know the core should be pretty similar to the Earth's. That is all just based on chemistry. And if you're a certain distance from a star, some elements and compounds will be solid, some will be gaseous and some things will be liquid, depending on how hot it is and whether there is any atmospheric pressure. It doesn't seem to matter what the star is like, whether it is a Sun-like star or a red dwarf, for example. The rocky planet should still have a similar composition.

Our detective work was simply based on the planets' sizes and masses. We can't yet measure the compositions of their atmospheres. However, new planets detected by Kepler in its K2 mission phase and by NASA's forthcoming Transiting Exoplanet Survey Satellite (TESS) might offer us this chance. There might be some planets that orbit very bright stars where you have high enough signal to noise to begin to look for the 'spectral fingerprints' that the atmosphere of the planet leaves on the light that passes through the atmosphere of the planet. These planets will be perfect targets for Hubble's successor, the James Webb Space Telescope.

ABOUT COURTNEY DRESSING

Graduate student Courtney Dressing is cooking up a storm in her 'kitchen', the astronomy department at Harvard University, part of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts

ISTOCK

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Revelation ASTRO DOBSONIANS

Sky at Night Magazine REVIEWED IN ISSUE 110 JULY 2014 ★★★★★

Sky at Night Magazine REVIEWED IN ISSUE 101 OCTOBER 2013 ★★★★★

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All prices correct at time of press. Subject to change. Errors and omissions excepted.

The Southern Hemisphere in April

With Glenn Dawes

WHEN TO USE THIS CHART

1 APR AT 00:00 UT
15 APR AT 23:00 UT
30 APR AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

APRIL HIGHLIGHTS

On the evening of the 4th a total eclipse of the Moon will be visible in its entirety from the eastern states. From Western Australia, mid-eclipse occurs 30 minutes after the end of astronomical twilight. Earth is only just inside the edge of the umbral shadow and totality will last only 12 minutes. The Moon's northern limb will likely look brighter. The partial phase starts at 20:15 EST (18:15 WST) and ends at 23:45 EST (21:45 WST), with greatest eclipse at 22:00 EST (20:00 WST).

STARS AND CONSTELLATIONS

Centaurus stands high in the south. Half-man and half-horse, its presence is betrayed by the names of its most prominent stars, the Pointers. Mag. +0.1 Alpha (α) Centauri is also known as Rigel Kentaurus (the foot of the Centaur). Mag. +0.6 Beta (β) Centauri is best known as Hadar, but also has a lesser-known ancient name: Agenda, meaning knee (of the Centaur). Although it looks slighter fainter than Rigel Kentaurus it is over 100 times more distant, meaning Agenda is the more luminous.

THE PLANETS

April is a great month for observing the most spectacular planets. The early evening sees Venus low in the northwestern twilight sky in Taurus, passing within 2° of the Pleiades on the 12th. At this time Jupiter is due north in Cancer, setting around 01:00 EST mid-month. Another gem rises around the end of twilight: the ringed world Saturn, which is then visible for the rest of the night. In the morning sky Uranus makes a return, rising just before dawn by month's end.

DEEP-SKY OBJECTS

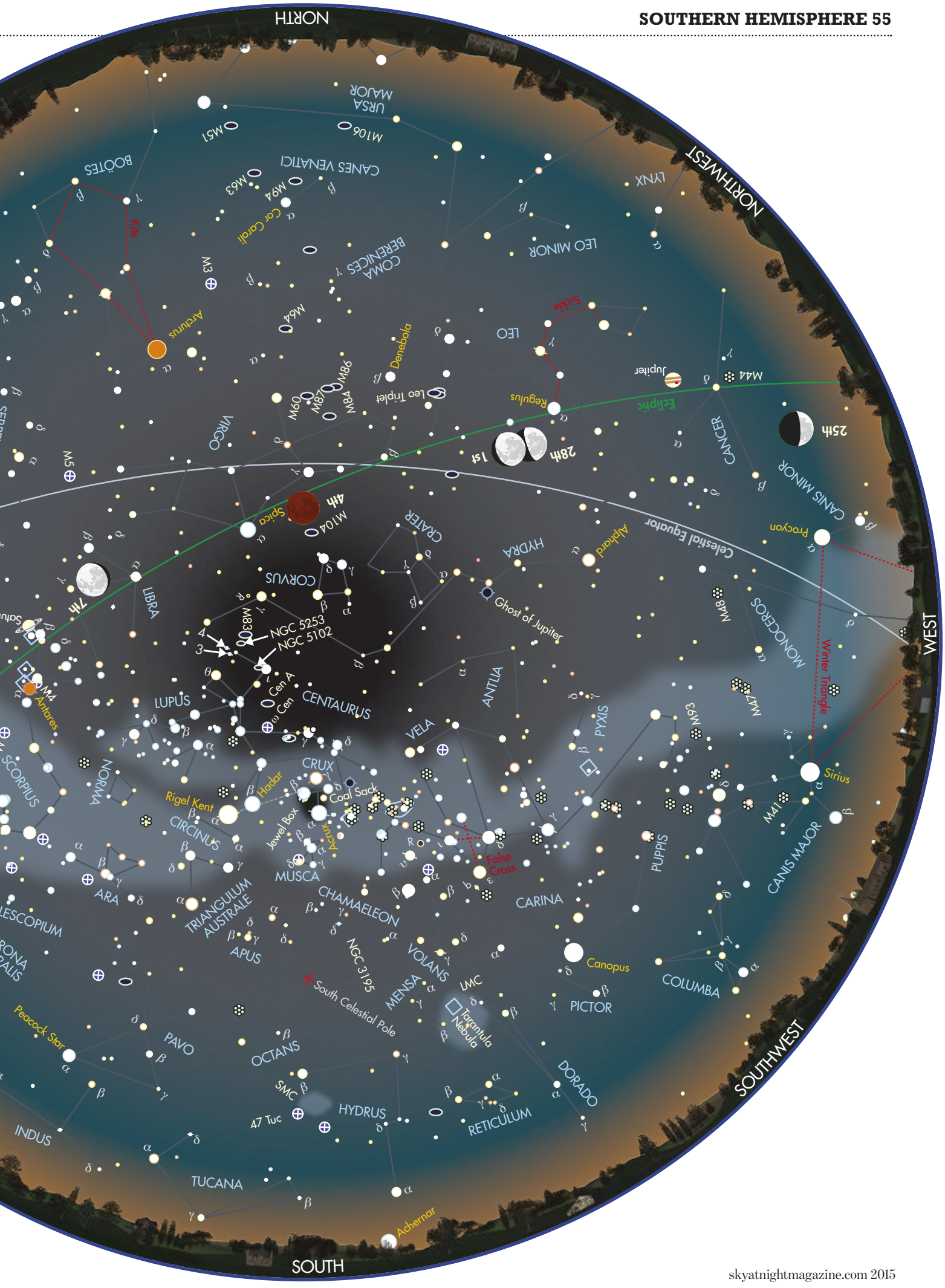
Centaurus is certainly full of great targets. Find mag. +2.1 Theta (θ) Centauri and move 4.5° northwest to find double star 3 Centauri (RA 13h 51.8m, dec. –32° 59'). It comprises two pale yellow stars of mag. +4.5 and +6.0, separated by a snug eight arcseconds. Only 1° north is 4 Centauri, another great double of mag. +4.6 and +8.5, a comfortable 15 arcseconds apart. One is yellow, the other white.

Travel 2.8° west of 4 Centauri to reach NGC 5253 (RA 13h 39.9m, dec. –31° 38'; pictured). This mag. +10.4 elongated spiral (3.5x1.5 arcminutes) has a bright, obvious oval core. Nearby spiral NGC 5102 (RA 13h 21.9m, dec. –36° 38'), is one of the easiest galaxies to find in the area, being only 16 arcminutes east of Iota (ι) Centauri. The galaxy is mag. +9.5, elongated with a brilliant extended core.

CHART KEY

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
URSA MAJOR
M51
M106
BOÖTES
CANES VENATICI
M63
M94
Cor Caroli
Kite
LYNX
LEO MINOR
COMA BERENICES
M3
M64
Arcturus
Denebola
LEO
Sickle
M86
M87
M84
M90
Leo Triplet
Jupiter
M44
Regulus
Ecliptic
25h
28h
1st
VIRGO
M5
CANCER
CANIS MINOR
4h
Spica
M104
CRATER
Procyon
Celestial Equator
HYDRA
Alphard
CORVUS
Ghost of Jupiter
7h
LIBRA
M83
NGC 5253
NGC 5102
M48
MONOCEROS
Winter Triangle
M4
Antares
LUPUS
Cen A
ω Cen
CENTAURUS
ANTLIA
PYXIS
M93
M47
VELA
CRUX
Hadar
Coal Sack
Rigel Kent
Jewel Box
Acrux
Sirius
M41
SCORPIUS
NORMA
CIRCINUS
False Cross
PUPPIS
CANIS MAJOR
MUSCA
ARA
TRIANGULUM AUSTRALE
CHAMAELEON
CARINA
APUS
NGC 3195
VOLANS
Canopus
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DORADO
47 Tuc
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INDUS
TUCANA
Achernar

UK Retailer Guide

Find the right one for you: buy your telescope from a specialist retailer

It is quite easy to become daunted by the vast array of equipment that is available to today's amateur astronomers. Different makes, different models, different sizes and optical arrangements – if you're new to the hobby, how do you make sense of all these details and find the telescope that will show you the Universe?

The answer lies in buying from a specialist retailer – somewhere that really knows what they're talking about. Like the retailers in this guide, they'll have the practical knowledge that will guide you towards the scope that won't end up gathering dust in a cupboard.

Today there are over 1,000 models of telescope to choose from – refractors and reflectors, Dobsonians and Newtonians, Schmidt- and Maksutov-Cassegrains. And just as important as the telescope is the mount it sits on; but do you go for equatorial or altazimuth, manual or Go-To? And what about accessories like eyepieces and finderscopes?

That's certainly a lot to consider before making a decision, but a specialist retailer will help you make that decision, taking important considerations like portability, construction and price into account.

So if you need friendly, face-to-face advice and excellent aftersales service, free from biased opinions, specialist telescope retailers are the place to go for a helping hand through the technical literature and tables of figures. They'll help you find a scope that combines quality and convenience at a price that's right.

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